

**EXPERIMENTAL STUDIES RELATING TO THE STORAGE
AND RIPENING OF SOME ORIENTAL AND HYBRID
PEARS, WITH VARIETY DESCRIPTIONS**

by

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INTRODUCTION

Pears stand as one of the exceedingly important tree fruits, both from the viewpoint of crop production and the human food consumption in the modern world. Not only are the fruits of attractive appearance, but of high nutritive value essential to human beings. There are more than twenty species and thousands of varieties with a wide range of distribution throughout the globe. In the past twenty years a considerable amount of experimental work has been done upon the handling of Occidental or European pear varieties, yet up to the present, the writer found little literature relating to the handling of the Oriental varieties so far as storage quality of these pears is concerned. Ordinarily, American pomologists have been interested in the Oriental and hybrid varieties largely as a source of stocks having the characters of blight resistance, vigor, and productiveness.

With this in mind, experiments were initiated during September, 1938, for the purpose of obtaining technical data pertaining to the storage and ripening behavior of seven Oriental and four hybrid pears under controlled conditions. The work began on September 14, 1938, and

was carried through the spring of 1939, covering a period of seven months.

This thesis is a detailed report of these investigations, and, in addition, records for the first time a number of variety descriptions of Oriental pear varieties. Apparently, these varieties differ widely from Occidental pears in their keeping and ripening characteristics, and it is hoped that these findings may stimulate further research in this interesting pomological group. The findings should be of interest to plant breeders who are interested in pears of long keeping quality and which possess the characteristic of blight resistance.

DESCRIPTION OF VARIETIES STUDIED

This work covers a total of eleven varieties, six of which are Chinese, namely, Hau Kai, Hung Li, Hung Guar Li, Hsiang Sui Li, Mi Li, and Tzu Ma Li; one Japanese variety, namely Japan Golden Russet; and four hybrid varieties, namely Conkleton, Garber, Le Conte, and Kieffer. All the varieties studied were at the Southern Branch Experiment Station, Talent, Oregon, which has the most comprehensive collection of pears in the world. Mr. F. C. Reimer, superintendent of the Station, who obtained a number of Chinese varieties during his exploration to China in 1919, is in charge of the collection and supplied the material for this work. Several workers have described the botanical characters of the Oriental species (Cox, Fite, Hu, Hedrich, Magness, Meyer, Ragan, Rehder, Reimer) while limited information on hybrids was given by Cox, Hedrich, Johnston, Meyer, and Reimer, but none on the variety descriptions except Kieffer, Garber, and Le Conte, under the Oregon conditions. It seemed, therefore, that a pomological knowledge of each variety being studied was desirable for better understanding of the background of the material, and the varietal descriptions are presented at the end of this paper. The botanical nature and distribution are also given in Table I. This table was prepared on information (22) given by the introducer to

the author, in which he made the following remarks concerning the treatment of the crop:

"The trees from which you obtained fruit are grafted trees and are twenty years old. These trees have been growing on silty clay loam soil. They are cultivated during the summer months and irrigated. During the late fall, winter, and spring a cover crop of Vetch is grown between the trees. No other fertilizer has been given."

Varieties studied in this work cover the main species of the Oriental type, but the best flavored of Chinese varieties, Tsu Li and Ya Li, have not been covered. Fruits of this type are characterized by the shape, color, and flesh texture of the fruit. They are more or less apple-like, few are pyriforme with calyx deciduous and peculiarly crisp in the texture of the flesh. The flavor is sweet with agreeable subacid. Color of deeper yellow or greenish yellow, often less aromatic than the communis or hybrid varieties. Trees adapted to cold, drought, and lighter soil.

Among four Chinese varieties studied, Hsiang Sui Li has the best flavor but is too small in size and of medium keeping quality, while Hung Li keeps much longer in the ripening room than any record ever found in literature with flavor only medium.

Hybrid varieties are readily recognized by American pomologists as blight resistant stock. Kieffer, Le Conte and Garber are the best known ones. They are leading varieties and are widely grown in sections of the United

States with too high summer temperatures for the communis variety. Fruits of the hybrids resemble the communis more than the Oriental parent, but are of lower quality as compared with the European sorts.

TABLE I

ORIGIN, DISTRIBUTION, AND BOTANICAL STATUS OF VARIETIES STUDIED

Variety	Species	Native	Distribution
Hsu Kai	<i>Pyrus ussuriensis</i> , Maxim.	Damogung	Hepoh Province, Manchuria, China Madford, Oregon, U. S. A.
Hsiang Hui Li	" " "	"	" " "
Hung Omar Li	Hybrid between <i>P. ussuriensis</i> and possibly <i>P. betulaefolia</i>	"	" " "
Hung Li	" " "	Man Lam Yi	Manchuria, North China Madford, Oregon, U. S. A.
Mi Li	" " "	" " "	Hepoh Province, Manchuria, China
Tsu Ma Li	" " "	" " "	" " "
Japan Golden Bunch	<i>Pyrus serotina</i> , Rehd.	Japan	Japan, Korea, Southeast sections U. S. A.
Cockleton	<i>Pyrus serotina</i> x <i>P. communis</i>	Texas	South sections U. S. A.
Garber	" " "	Calabria	Pennsylvania, south sections U. S. A.
Le Combe	" " "	Liberty County	Georgia, southern sections U. S. A.
Kieffer	" " "	Philadelphia, Penn.	A leading variety in all sections of U. S. except Washington, Oregon, California, western New York. It has district of Texas; Tsingtao, Chefoo, China

METHODS OF PROCEDURE

THE MATERIAL: Southern Oregon Branch Experiment Station, Talent, Oregon, is the source of the material used. Trees that bore good fruits with proper maturity were selected for the experiment. This involved a total number of eleven varieties. Fruits were picked September 14 and 15, 1938. It was extremely hot during that time late in the fall, ninety-four degrees Fahrenheit being the prevailing mid-day temperature.

PICKING: Fruit was picked from different sides of the tree so as to render the sample as representative as possible. In some varieties which had attained a higher degree of maturity, only the greener fruit was picked, in order that a longer storage life might be obtained.

FIRMNESS TEST: Firmness determination was made in the orchard shortly after picking, using the Oregon type pressure tester with a plunger of seven-sixteenths of an inch diameter. Firmness reading of each variety is taken from three sides of an unpared fruit, and three to five fruits for each variety.

STORAGE: The picked fruit was placed in pear boxes and hauled to storage within two hours after picking. In so doing, the ripening process of the fruit after picking was reduced to a minimum. The storage room located in Medford, Oregon, has excellent refrigerating

facilities, having controlled temperature and humidity. A temperature of 31° F. with no variation of more than two degrees and a relative humidity of 78-85% were maintained in the room. No treatment such as washing and wrapping was given to the fruit prior to storage. Boxes were piled with ample space between to provide adequate air circulation. Samples for the experiment were divided into (1) short storage and (2) long storage. The first lot was stored for a period of fifty-five days and then was removed to the ripening room. The second lot was kept in cold storage until April 7, 1939, (205 days), following which it was placed in the ripening room and handled in the same manner as lot one.

RIPENING: The ripening room, located at Corvallis, was maintained at a temperature which varied between 65° and 70° F. A high humidity was maintained to prevent wilt. During the ripening period observations were made as to the following: (1) changes in pressure readings, (2) number of days required to reach prime condition, (3) color changes, scald, and other symptoms of breakdown, (4) eating quality, juiciness, texture, sweetness, acidity, and aroma.

TESTS FOR THE PRESENCE OF ETHYLENE GAS IN ORIENTAL PEARS: Since the common varieties of pears evolve ethylene gas during certain stages of maturation, and since this gas is essential to ripening, tests were made with Oriental

pears to determine whether these also evolved the gas. The method of testing was that of Hansen and Hartman (Ore. State Bul. 352) (5). By this method the occurrence of ethylene is determined by noting the effects of the gas on germinating seedlings and on tomato plants.

PRESENTATION OF DATA

The data obtained in the course of these studies is recorded in Tables II to VII inclusive.

TABLE II--DATA ON STORAGE

Picked and stored at 31-32° F. Sept. 14-15, 1938; Removed Nov. 8, 1938; Humidity 80-85%

Variety	Average Firmness (in lbs.) When Picked	Days in Storage	Firmness After Storage	Condition
Hau Kai	14	55	16.3	Firm and green
Haiang Sui Li	12.4	55	13.3	Slightly firm, yellow
Hung Guar	14.1	56	16.5	Firm, yellowish green
Hung Li	16.8	55	18.3	Very firm, green
Mi Li	13.4	55	17.0	Firm, green
Tsu Ma Li	23.8	55	28.1	Firm, green
Japan Golden Russet	16.4	56	21.4	Firm, green russet
Comkleton	18.3	56	21.0	Firm, green
Garber	13.5	56	17.2	Firm, green
Le Conte	18.2	56	19.8	Firm, green
Kieffer	21.2	56	23.3	Firm, reddish green

TABLE III--DATA ON STORAGE

Picked and stored Sept. 14-15, 1938; Removed April 8, 1939

Variety	Average Firmness When Picked (lbs.)	Storage Temp.	Days in Storage	Firmness After Storage	Condition
Hau Kai	11.4	31-32° F.	206	11.5	Firm, gray-green, flesh discoloration
Hsiang Sui Li	12.4	"	206	13.5	Fairly firm, yellow, scald
Bung Guar Li	14.1	"	205	16.5	Firm, reddish green
Hung Li	16.8	"	206	18.5	Green, very firm
Mi Li	13.4	"	206	16.0	Firm, green
Tsu Ma Li	23.0	"	206	24.5	Firm yellowish green
Japan Golden Russet	16.4	"	205	21.5	Firm, green russet
Conkleton	18.3	"	205	19.7	Firm, green
Garber	13.5	"	205	17.0	Firm, yellowish green
Le Conte	18.2	"	205	19.0	Firm, darkening tissues
Kieffer	21.2	"	205	21.5	Firm, reddish green

TABLE IV--DATA ON RESULT OF RIPENING

Dates of Removal from 31° F. Storage; (A) Nov. 8, 1938, (B) April 9, 1939
 Ripening temperature 65-68° F.; Humidity 80-85%

Variety	Days in Storage	Dates of R Ripening	Date Attained Prime Condition	Firmness (lbs.)	Days to Reach Prime Condition
Hau Kai	(A) 55	11/9/1938	11/21/1938	19/0	15
	(B) 206	4/9/1939	Darkening	Not ripened	Internal discoloring
Hsiang Sui Li	(A) 55	11/9/1938	11/21/1938	5.0	15
	(B) 206	4/9/1939	4/16/1939	8.0	8
Hung Guar Li	(A) 56	11/9/1938	11/20/1938	7.0	11
	(B) 205	4/9/1939	4/19/1939	5.0	10
Hung Li	(A) 55	11/9/1938	12/18/1938	27.0	39
	(B) 206	4/9/1939	5/11/1939	25.0	32
Mi Li	(A) 55	11/9/1938	12/15/1938	20.8	36
	(B) 206	4/9/1939	5/4/1939	21.0	25
Tsu Ma Li	(A) 55	11/9/1938	11/16/1938	7.0	7
	(B) 206	4/9/1939	4/18/1939	13.0	9
Japan Golden Russet	(A) 56	11/9/1938	11/21/1938	20.5	15
	(B) 205	4/9/1939	4/21/1939	19.5	15
Conkleton	(A) 56	11/9/1938	11/20/1938	9.0	11
	(B) 205	4/9/1939	4/20/1939	5.5	10
Garber	(A) 56	11/9/1938	11/20/1938	10.0	11
	(B) 205	4/9/1939	4/19/1939	9.0	9
Le Conte	(A) 56	11/9/1938	11/11/1938	8.0	5
	(B) 205	4/9/1939	Darkening	Not ripened	Breakdown
Kieffer	(A) 56	11/9/1938	11/17/1938	7.0	8
	(B) 205	4/9/1939	4/16/1939	6.0	7

TABLE V--DATA ON KEEPING QUALITY (FIRST RUN)

Variety	Days in 31° F. Storage	Days to Attain Prime Condition	Days Marketable
Hag Kai	55	15	23
Hsiang Sui Li	55	15	22
Hung Guar Li	56	11	28
Hung Li	55	39	200
Mi Li	55	36	150
Tsu Ma Li	55	7	28
Japan Golden Russet	56	11	27
Conkleton	56	11	15
Garber	56	11	15
Le Conte	56	5	10
Kieffer	56	8	20-25

TABLE VI--DATA ON KEEPING QUALITY (LAST RUN)

Variety	Days in 31° F. Storage	Days to Reach Prime Condition	Days Marketable
Hau Kai	206	Intermal discoloration	--
Hsiang Sui Li	206	8	12
Hung Guar Li	205	10	23
Hung Li	206	32	180
Mi Li	206	25	120
Tsu Ma Li	206	9	15
Japan Golden Russet	205	15	25
Conkleton	205	10	12
Garber	205	9	15
Le Conte	205	Breakdown	--
Kieffer	205	7	20

TABLE VII--DATA ON THE TEST OF OCCURANCE OF ETHYLENE

Variety	Species	Days in 31° F. Storage	Days in Ripening Room	Effect on Tomato Plant
Hau Kai	<i>P. ussuriensis</i>	206	10	Moderate epinasty
Hsiang Sui Li	"	206	10	Moderate effect
Hung Guar Li	"	205	11	Slight effect
Hung Li	"	206	11	No epinasty
Mi Li	"	206	11	No epinasty
Tsu Ma Li	"	206	11	No epinasty
Japan Golden Russet	<i>P. serotina</i>	205	11	No epinasty
Conkleton	Hybrid	205	10	Marked epinasty
Garber	"	205	11	Marked epinasty
Le Conte	"	205	10	Slight effect
Kieffer	"	205	10	Marked epinasty

DISCUSSION

This paper is mainly concerned with the following viewpoints: (1) storage at cool temperature, (2) ripening at room temperature, and (3) duration or period for which fruit can be kept under storage and ripening conditions. Since Kieffer is a leading variety in the United States with flavor and quality beyond all eleven varieties studied and good results were obtained with it, more attention was given to this variety.

STORAGE TEMPERATURE: On the first run all fruits having been kept in 31-32° F. storage for a period of fifty-five to fifty-six days remained in normal and sound condition just as well as at the time they were picked. Fruit of all varieties showed green, firm, bright color and neat appearance. Ripening was effectively checked, and no trace of low temperature injury, bacterial breakdown, mold or decay could be found in any sample. Fruits when removed to the ripening room ripened well and developed the dessert quality in every case normal for the variety. For the last lot a longer storage period had been given, but most varieties showed no injury or other defects that could be accounted for as a result of cold storage temperature, except in Le Conte, which showed physiological breakdown due to too long storage. Results thus far confirmed that uniform refrigerating

condition with a temperature range of 31-32° F. is by far the most successful and excellent method for those Oriental and hybrid varieties as it is for the communis varieties.

CHANGE IN FIRMNESS: As shown in Tables II to IV the changes in firmness of flesh vary with the different varieties and different treatments. The pressure readings showed in most instances an increasing resistance for both runs, instead of a decreasing one as commonly occurs. It was recognized that the readings after harvesting were made during the season with a high prevailing atmospheric temperature. Under such conditions, undoubtedly the fruit must have attained high temperature, increasing the turgidity or lowering the resistance of the fruit skin to the pressure tester. In addition, the fruit remaining in cold storage for a certain period, considerable shrivelling developed, causing the skin of the fruit to become toughened, and tending to increase the resistance of the fruit skin to the pressure tester. It should be pointed out further, that one of the characteristics of the Oriental varieties as distinguished from the communis sort is the crispness in texture of flesh, which remains crisp even though the normal ripening and the prime eating condition is reached. In the case of Hung Li, a long keeper, on the first run after a period of fifty-five days in storage, instead of softening, the pressure

reading increased. This was due to the toughening of skin, caused by evaporation of moisture from the fruit. Such a condition is noticeable for the Oriental type when fruit is kept in the ripening room for a long period. Data also showed that the firmness in all varieties in the last run is still higher than the readings made after being picked, but is slightly lower than the record shown on the lot first removed from storage. A variety with such crisp flesh in nature tends to increase the pressure reading or firmness of flesh up to a certain point, then drop but slightly until the fruit is broken down. In fact, the amount of fruit available for this experiment was rather limited and the samples were too scarce and variable for precise results.

The changes in the firmness of flesh of the hybrid varieties during ripening are similar to those of the communis varieties. The difference is marked between the readings of prior and after ripening. When in the overripe stage, fruit is soft and surface breakdown or fungous attack is common.

RIPENING TEMPERATURE: It has long been known that pears should not be ripened in cold storage, but should be ripened at fairly high temperatures (8). Experimental lots having kept for designated periods were subjected to a temperature of 65-68° F. for ripening. This

procedure enables most varieties to attain a rapid rate of ripening and optimum dessert quality. Except the Le Conte and Hau Kai, which developed physiological breakdown before ripening, all varieties attained normal condition and developed dessert quality satisfactorily after being kept several days in the ripening room. Good results were obtained especially on the Kieffer pear, while those of the crisp flesh varieties did not ripen as sensitively as those of the common sort under this range of temperature.

RATE OF RIPENING: Experimental work by a number of investigators show that at a temperature around 65° F. for common communis varieties such as Bartlett, Bosc, Anjou Comice and Winter Nelis at optimum picking date and to optimum dessert quality, the time required to reach prime eating condition during ripening is approximately a week to ten days. When the fruit is picked too early or too ripe the time required is longer or shorter, but only fair quality can be obtained (6) (7) (8) (13). Tindale (23) worked on Australian Williams Bon Chretien pears and found that when stored at 30 °F. for a period of eight to ten weeks, the fruit takes six days to ripen and the time required will lengthen or shorten when the fruit is held for a longer or shorter period, while Lutz in Maryland reported that the Kieffer requires a period of sixteen to twenty days at 65° F. to develop the

optimum dessert quality most desirable.

The number of days or the rate at which the fruit came to prime condition during ripening showed a great variation between different varieties, maturity of fruit when picked and the length of storage. In general, fruits of the last run having longer duration in storage ripen quicker than the first. Results also indicated that hybrid varieties have a quicker rate of ripening, while the Oriental varieties are generally slow. On the first run, Le Conte took a period of five days to ripen, representing the greatest rapidity in rate of ripening, but has the poorest keeping quality as will be shown later. It is interesting to note that the two Chinese varieties, Hung Li and Mi Li, took a month or more to attain ripeness. Probably the fruit had not been picked in the right stage of maturity for proper development of dessert quality. This may account for such slow ripening for normal condition, but it should not be overlooked that these are crisp flesh varieties and that they did develop normal condition and quality up to the designated period and in the ripening room and remained alive without decay at the ripening temperature even beyond the time when this paper was completely written. Meyer (15) found in China that, "The Liu Yucca Li in Kuangning, Manchuria needs to be kept for six months before it acquires the right flavor." Accordingly, those varieties

mentioned took such a long period to ripen and can still be kept in the ripening room for a period of six months or more is by no means surprising.

Hsiang Sui Li, which was considerably too mature for storage when it was picked, became too ripe sooner than the other Chinese varieties, while Hung Guar Li and Tzu Ma Li, which are tender flesh varieties, took even shorter time than the Hsiang Sui Li.

Hybrid varieties became too ripe at the ordinary rate as in the case of the communis varieties.

Relating to the last run, it is evident that the long storage period materially hastens the rate of ripening in most varieties tested. Take, for instance, the Kieffer, which has been kept for fifty-six days in cold storage and required a period of eight days to ripen, while those kept for two hundred six days required only seven days or less, an increase of 10-15% in the rate. Other varieties showed much the same trend. These results agreed with most of the former investigators.

CONDITION AND QUALITY DEVELOPED DURING RIPENING:

Different varieties respond differently when subjected to the same ripening temperature. It has been found that the condition and quality developed during ripening is associated with the maturity of the fruit when it was picked. Fruit picked at the right stage of maturity will develop the best quality without any defects or

abnormalities during ripening. Results of this work highly support this statement; only Hsiang Sui Li, Hung Guar Li, Conkleton, Garber, and Kieffer resulted with this condition. Those fruits that were picked too early did not develop properly during ripening; color did not attain its full intensity, quality was low, the flesh was not juicy, and the tissues tended to shrivel. Loss of juiciness and becoming mealy, poor keeping quality, susceptibility to breakdown, development of decay and the attacking of mold rots were common. Hau Kai, Tzu Ma Li, and Japan Golden Russet were found to be slightly affected by this condition. Fruit left in a semi-ripe condition with no development of color shrivelled soon after ripening, as in the communis varieties. When the fruit attained prime eating condition it was characterized by (1) full development of color, fading away of chlorophyll and coming out of yellow at the end of about one week at the ripening temperature; (2) full development of dessert quality with medium firm flesh, juicy and sweet; (3) clean appearance, free from blemishes. The tender fleshed hybrids, such as Conkleton, Garber, Le Conte and Kieffer have the same ripening behavior as the communis sorts. Of the hybrids studied, Kieffer was the outstanding variety. The most striking phenomenon of the behavior of the hybrids is the disappearing of green color and the softening of flesh after about one week of

ripening. Kieffer took a period of seven to eight days to attain the prime eating condition and showed a decrease of firmness or softening of the flesh at the rate of two pounds pressure for each day in the ripening room.

On the other hand, the crisp flesh types of the Chinese varieties, especially Hung Li and Mi Li, showed an increase in crispness of the flesh instead of softening as prime condition was attained. It was found that the green color in the surface of Hung Li and Mi Li held in 31° F. storage for fifty-six days and removed to 68° F. ripening room did not change to yellow until a period of twenty-five days in room temperature. The fruit remained green and firm with no marked change of color or maturity and dessert quality. It seemed that the ripening treatment at 65° to 68° F. had but little effect upon the firm fleshed sorts. Fruits of the first run placed in the ripening room in November stayed till May with the flesh crisp, fairly juicy and of fair quality. A few of the specimens became diseased with penicillium and soft rot. The skin in some cases showed brownish spots and considerable shrivel. It appears that ripening of these sorts should be continued only to the point where maximum sweetness has been attained, where good color has developed, and where a breaking condition of the flesh has been reached. The physiology of these pears during their ripening period offers an excellent

problem for research.

The hybrid varieties behave differently in that they rapidly become soft and overripe. Garber, Le Conte, and Conkleton become dry and mealy, show skin discoloration and break down quickly. They are attacked by mold in a short time. Kieffer keeps somewhat longer than do the other hybrid varieties.

KEEPING QUALITY AFTER RIPENING: The keeping quality of a variety is determined by (1) the condition of the fruit after removal from the designated storage period, (2) the number of days required to attain prime eating condition at ripening temperature, and (3) the period during which the fruit remains marketable after ripening.

On the first run, a short storage period was allowed for various varieties. As shown in Table V, all varieties attained the normal condition and quality after cold storage and during ripening. It will be seen clearly that the hybrid varieties do not keep very long when they reach the ripe condition. They, especially Le Conte, are susceptible to ordinary physiological disorders such as core breakdown and skin discoloration. In the overripe stage they are subject to surface breakdown accompanying the attacking of mold and decay. The tender flesh type pears are limited to a total marketable period of three weeks. Surprisingly, the Chinese crisp-flesh type varieties that take a longer time to develop dessert

quality remain in the ripe stage for quite a long time and are highly free from decay when kept under room temperature over a long period of time. Take for example the Hung Li, which did not show any decay until two months later in the ripening room and was not attacked by blue mold for as long as three months in the ripening room. Just how high the degree of resistance to mold invasion of this variety is, would be an interesting subject for investigation.

These results indicate the possibility of keeping two Chinese varieties, Hung Li and Mi Li, over a period of one year or more under cold storage and six months under no refrigeration.

On the last run, in which fruits were treated with a longer cold storage period, a marked difference of condition between varieties was noted. Conkleton, Garber, and Kieffer remained in normal condition upon removal from storage as before and proceeded with proper ripening. Le Conte, the only poor keeper among the four hybrids, had broken down. Fruit of this variety was severely scalded showing darkening in the skin. The flesh showed brown discoloration; the core was flooded with water; empty pockets were found in the pith regions, and the fruit had a disagreeable odor. The flesh, however, remained firm. Overholser, in his study of more than forty communis varieties, realized this variety was a poor keeper. His data showed that this variety can be

kept at an optimum storage period of fifty-five days and a maximum period of about one hundred days at 32° F. It is evident that the keeping quality of a variety is governed by its inherent character by which the cold storage is limited to a definite period even under uniform and controlled conditions. Any attempt to go beyond the limit can only lead to failure.

Garber and Conkleton stood well after 205 days in cold storage. Garber proved to be a little better keeper than Conkleton, for the latter one is susceptible to scalding and surface breakdown earlier than the first. Garber, however, has the drawback of gray discoloration or some black markings shown five or six days after reaching the prime condition.

The most satisfactory results were those obtained with Kieffer, which possesses the best flavor and quality of all the hybrids. The length of cold storage period of 205 days seemed to have not much effect upon the life and quality of this variety. Upon removal from cold storage the fruit showed a certain amount of yellow color, indicating the maturity of the fruit had progressed to some extent. The fruit proceeded to ripen properly with full development of skin color and dessert quality after seven days in the ripening room. Data on Lutz's work (13) showed that to avoid deterioration of quality the storage life of Maryland Kieffer pears at

32° F. is limited to approximately ninety days, while Overholser (17) reported that the maximum cold storage period for California grown Kieffer pears is two hundred and three days but the fruit resulting attains only fair quality. The result of this work does not entirely agree with this statement, under Oregon conditions, but it may be considered as supplemental rather than differential in respect to such diversity of locality.

Results so far proved that Kieffer is superior in keeping quality to many of the communis varieties. Such features as attractive color and shape, desirable tree characters, wide distribution in cultivation, in addition to the keeping quality, make this variety appear to have many possibilities.

ETHYLENE PRODUCTION: As shown in Table VII, it is interesting to note that the occurrence of ethylene and the keeping quality of pears seemed to be associated with the different species. Most Oriental varieties studied produced little effect of epinasty on tomato plants, while the hybrids cause marked curvature of tomato leaves. This effect is interesting in the phase of pear handling and more accurate chemical determination of this particular nature needs further investigation.

It was observed that those tender fleshed varieties are of such perishable nature that they cannot stand

transportation or handling as well as the Chinese crisp flesh varieties.

It may be concluded that Chinese pears differ from the common pear in many respects: not only in the tree characters but in the fruit character, either morphological, chemical, or physiological. Such features as the exceedingly long keeping quality, freedom from physiological breakdown and other defects, and high degree of resistance to mold invasion, are features peculiar to these pears and indicate a far different handling treatment than that employed in America with the communis varieties.

VARIETAL BEHAVIOR

1. HAU KAI

This variety was found to be a poor keeper in cold storage. It had the shortest storage period of any of the five Chinese varieties studied.

On the first run, fruit having been kept in cold storage for fifty-five days remained in sound condition and attained prime condition after a relatively long period. The fruit is relatively free from decay or the attack of mold, but is susceptible to brown discoloration of flesh, which cannot be detected without cutting the fruit for inspection. This defect occurred at about twenty days following the first day of ripening, or the seventh day after the prime condition was attained. It was thought to be a condition of fruit prematurely picked. On the last run, a marked difference was noted in the fruit. It appeared grayish green in color, and the flesh was spongy and discolored, indicating that physiological breakdown had occurred long before removal from cold storage. On tasting the fruit, the flavor was objectionable but slightly sweet, juicy, with a very little bitter, and no disagreeable odor. No ripening occurred during the period the fruit was in the ripening room. Bruised parts of the fruit were attacked by penicillium.

2. HSIANG SUI LI

The fruit had attained full maturity when it was picked. After fifty-five days of cold storage, the fruit remained in sound condition and ripened with good quality; but when held for two hundred and six days, a considerable amount of scald was noted, yet normal quality developed during ripening. The flavor was by no means abnormal or disagreeable but some of the quality seemed to have been lost due to prolonged storage. The brown discoloration of skin impaired the appearance and reduced commercial value. The texture of the flesh was slightly affected by scalding. Though the fruit suffered from scalding, the tissues remain free from decay or breakdown in the ripening room for as long a period as twenty-five days.

The chief cause of failure to keep resulted from surface breakdown, accompanied by mold.

3. HUNG LI

This variety possesses long keeping quality. It was thought that the fruit was picked too early. Despite the fact that it kept well after two hundred and six days in cold storage, the larger portion of the first run remained alive without breaking down for more than six months in the ripening temperature. Although the skin showed severe wilting and a few brown spots the flesh and flavor was by

no means abnormal or objectionable. Only a small portion of the crop was discarded from mold invasion and breakdown. It takes a month or so for coming out of yellow skin color under 65-68° F. temperature. The flesh becomes more crisp after a long period in the ripening room.

4. HUNG GUAR LI

This variety possesses attractive color, aroma, and a bright neat skin, but falls down in quality. The texture is somewhat tender with numerous undesirable grit cells. The fruit developed normal quality both after fifty-six and two hundred and six days in 31° F. storage and subsequent ripening. The fruit was juicy as it came out of cold storage but became slightly mealy soon after reaching prime condition. The skin retained its bright color and neat appearance even after twenty days in the ripening room, with few black spottings or discoloration occurring in the overripe stage.

5. JAPAN GOLDEN RUSSET

According to Cox (3) the maturing season of this variety is some time around October. The fruit for these tests was picked too early for best results. On removal after the fifty-six and two hundred and five days in cold storage, it remained in good condition, firm and green with no decay. During ripening it took almost two weeks to fade away the green color. Fruits did not develop full color and quality successfully on both runs. The fruit remained in a semi-ripe condition but shrivelled badly in the ripening room. The variety showed considerable resistance to mold invasion and remained free from physiological disorders. *Penicillium* did not appear until two months after ripening.

6. MI LI

The fruit has the characteristics of crisp flesh, long keeping quality, and freedom from decay. It resembles Hung Li in storage behavior. It appears to be an even more consistent keeper than the Hung Li. It takes a month or so for the fruit to be ready for marketing. Fruits held for two hundred and six days in 31° F. storage ripened in a normal manner. No other defects could be detected after long cold storage. The chief loss in value was the wilting and breakdown.

7. TZU MA LI

Apparently the samples of this variety were harvested prematurely and remained in this condition during the ripening period. No defects could be noted after two hundred and six days in cold storage. The variety is susceptible to brown russet markings on the skin which develop after a few days in the ripening room, making the fruit appear blemished. The fruit became tender with dull color after nine days at ripening temperature. They developed considerable wilt during the ripening period.

8. CONKLETON

The fruit showed no defects upon removal from cold storage and ripened in a normal manner. The flesh of the fruit was fairly firm and moderately juicy after ripening, but became mealy when kept long. The variety proved to be susceptible to gray discoloration and breakdown on the surface. All fruits were of no value after three weeks in the ripening temperature. The variety developed considerable rot after three weeks in the ripening room.

9. GARBER

The fruit of this variety ripened normally in the case of both storage runs. The variety is susceptible

to dull gray markings on the surface, detracting from the market value. This was noticeable after fifteen days in the ripening room. The fruit remains firm slightly longer than does Conkleton. The variety developed rots after a considerable period in the ripening room.

10. LE CONTE

This variety was found to be the poorest keeper among the eleven varieties studied. After fifty-six days of cold storage, the fruit was in good condition and capable of ripening normally at a short period of five days at 65-68° F. It has poor dessert quality and is susceptible to core breakdown when kept in the ripening temperature for considerable time. Fruit kept for two hundred and five days in cold storage showed tissues darkened internally and externally. It was observed when removed from storage that the surface color of the fruit is partly green and partly blackened. The flesh is fairly firm, spongy, brownish white, slightly juicy, and the core is flooded with water. Empty air pockets about one-half of a centimeter in diameter were formed in the pith regions. It tastes slightly sweet but with a disagreeable odor. The fruit did not ripen when brought to the ripening temperature. Green color remained dead and shading away by breakdown of tissue, accompanied by core breakdown.

Mold decay developed as early as three days in the warm room. The inferior dessert quality together with poor keeping quality of this variety are pronounced.

11. KIEFFER

The desirable features of this variety are its keeping quality and fine dessert quality. No defects can be detected from the first and second run removal from cold storage. Fruit showed somewhat yellower from the last run than from the first lot removed from storage, but showed neat appearance, firm and sound condition. Best color and optimum dessert quality were obtained after two hundred and five days cold storage and seven days in ripening temperature. Fruit showed slight gray discoloration and surface breakdown on mechanically injured areas in six days after reaching prime eating condition, but the quality retention is far better than the other hybrid varieties. The fruit held up to two weeks in good condition with a total marketable period of twenty-five days in the ripening temperature. The one objection to this variety is the gritty cells near the core. However, such desirable features as attractive color and shape, resistance to fire blight and San Jose Scale, long storage quality, uniformity of ripening and superior dessert quality give this pear much commercial possibility.

SUMMARY

The results of this experiment showed that Chinese varieties are exceedingly long keepers. This is especially true of Hung Li (Red pear) and Mi Li (Honey pear). These varieties remain good after six months at 31° F. storage and can be kept in ripening temperature of 65° to 68° F. for over a half year with retention of reasonable quality. They are crisp fleshed, immune to blue mold and highly free from common physiological disorders.

The keeping quality of a variety is associated with maturity of the fruit when it was picked and the rate of ripening; generally Chinese varieties take a longer time to attain prime condition, but with a longer marketable period and are relatively free from decay during ripening. The length of storage period materially affects the rate of ripening. A longer storage period decreases the time required for the fruit to ripen.

Experiments indicate that Oriental varieties generally produce little ethylene gas during ripening.

Kieffer is capable of being held in cold storage for a period of two hundred and five days and ripening with optimum flavor and quality at 65° to 68° F.

Le Conte was found to be a very poor keeper, and showed heavy scald and physiological breakdown after two hundred and five days in cold storage.

Hybrid varieties are of tender flesh and of high susceptibility to the attack of blue mold and breakdown. The keeping quality of the four hybrid varieties may be arranged as follows: Kieffer, Garber, Conkleton, Le Conte.

A number of Chinese varieties are described for the first time.

It appears that Chinese pears in general offer possibilities as breeding stocks in the development of pear varieties.

VARIETY DESCRIPTIONS

Hau Kai Li

Chinese Meaning	Floral Cover Pear
Species	<i>Pyrus ussuriensis</i> , Maxim (21)
Native	Kuangning, Manchuria, China
Distribution	Hopeh, Manchuria, China; Medford, Oregon
Illustration	Plate I

Size small to below medium, fairly uniform, one sample 4.8 x 4.1 cm. weighed 53.5 gm.; shape globular, symmetrical color yellow and washed lightly with brown in the exposed side; dots numerous, medium, uniform, conspicuous, russeted areola; skin rough, medium thick and tough; stem medium thick, same color as the skin, fleshy, medium long; cavity narrow, shallow, obtuse, regular, smooth, sometimes lipped; basin shallow, narrow, obtuse, irregular, slightly wrinkled; calyx persistent, sometimes deciduous, widely opened, lobes separated at base, recurved, curving inward, calyx-tube conical, medium wide and long, red russeted with pubescent; stamens persistent, sometimes deciduous, basal; core large, axile, median, medium size, closed, core-line clasping; carpel round ovate, emarginate; cells axile, symmetrical, smooth; flesh white to yellow, crisp, coarse, somewhat juicy; flavor subacid; quality poor to fair; seeds nine in number with five undeveloped, medium size, slightly acuminate, plump, almost black.

Hsiang Sui Li

Chinese Meaning	Fragrant Water Pear
Species	A hybrid between <i>P. ussuriensis</i> and some other species, possibly <i>P. betulacifolia</i> (22)
Native	Kuangning, Manchuria, China (22)
Distribution	Hopeh, Manchuria, China; Medford Oregon, United States
Illustration	Plate II

Size below medium, not uniform; one sample 4.9 x 4.3 cm. weighed 47.5 gm.; shape obvate, irregular, sometimes slightly ovate; color shiny bright yellow; dots numerous, small, russeted, more or less conspicuous; skin not entirely smooth, tender, thin; stem medium long, 1.5-2.0 cm.; thick, fleshy; cavity obtuse, very shallow and narrow, with practically no depression, fleshy around the base of the stem, smooth, lipped, irregular; basin narrow, shallow to almost flat, slightly wrinkled; calyx persistent, open, erect, lobes short, united at base, acute, median, stiff, somewhat leathery, calyx-tube wide, conical, shallow; stamens persistent, marginal; core, median, medium size, core-line meeting; carpel ovate, emarginate, cells symmetrical, smooth wall; flesh yellowish white, fine and tender, very juicy; flavor sweet with mild acid; quality good to very good; seeds large, obvate turbinate, plump, obtuse, few were undeveloped, black, shiny.

Hung Li

Chinese Meaning	Red Pear
Species	A hybrid between <i>P. ussuriensis</i> and some other species, possibly <i>P. betulaeifolia</i> (22)
Native	Man Lan Yi, Peking, China
Distribution	Manchuria and northern China
Illustration	Plate III

Size medium to below medium, not uniform, one sample 5.7 cm. x 3.5 cm. weighed 107.5 gm.; shape irregular round oblong; color light yellow sometimes blushed with bright red cheek, more intense near the stem and gradually fading to the calyx end; dots numerous, both large and small, distributed all over the surface, size larger on the blushed side, conspicuous, irregular, reddish with russet center, raised; skin medium thick, rough, very tough, more or less dull; stem long, woody, medium thick, 3.9 cm. in length, reddish brown; cavity deep, medium narrow, acuminate irregular, slightly furrowed, color yellow; basin deep, medium wide, smooth, round, not symmetrical; calyx deciduous sometimes persistent, reduced to hard tissue enclosed in the calyx-cup; stamens deciduous, sometimes persistent; core medium, median to distant, fairly axile, closed, core-line clasping; carpel ovate, symmetrical, emarginate; cells axile smooth; flesh yellowish white, crisp and breaking, juicy, slightly coarse in texture; flavor mild, slightly sweet; quality fairly good; seeds medium to small, ten in number,

black color, long, acute, few were undeveloped.

Hung Guar Li

Chinese meaning	Red Irrigated or Red Can Pear
Species	A hybrid of <i>P. ussuriensis</i> and some other species, possibly <i>P. betulaeifolia</i> (22)
Native	Kuangning, Manchuria China
Distribution	Hopah, Manchuria, China
Illustration	Plate VI

Size below medium, not uniform, one sample 6.3 cm. x 5.5 cm.; shape round ovate, with wider equatorial diameter; color yellow covered with red dots in the exposed cheek; dots numerous, size not uniform, more conspicuous and larger on the exposed surface, irregular, red with roundish and slightly angular raised russet center; skin thin, not very dull, smoothed to slightly rough, tender; stem medium thick, 2 cm. in length, brown to black, stiff; cavity smaller than the basin, obtuse, very narrow, sometimes lipped, shallow; basin medium deep, narrow, flaring, irregular, with concentric russet rings; calyx deciduous, calyx-tube conical, reduced to hard enclosed tissue; stamen deciduous; core medium, distant, axile, closed, stone cells large around the core; core-line meeting; carpel ovate, emarginate, irregular; cells axile, smooth, axile-sac tufted; flesh yellowish white, slightly rough, coarse, tender, somewhat juicy, many grit cells around core; flavor neutral, aromatic; quality fair to good; seeds large, acuminate, plump, narrow at base with dark red color.

Japan Golden Russet

Species *Pyrus serotina*, Rehder

Native Japan

Distribution Korea; Japan; southeastern sections
of United States (3)

Illustration Plate II

Size medium to above medium, fairly uniform, one sample 6.5 cm. x 4.5 cm. weighed 151 gm.; shape globular oblate, apex flattened, regular; color golden russet to light brown with heavily spotted yellow dots; dots numerous, dull yellow, slightly raised, russetted, areola, thickly scattered over the entire surface, smaller near the apex; skin rough, thick and tough, leathery; stem long, thick, 4 cm. in length, of brownish green color, with russet dots; cavity acute, medium wide and deep, lipped dots going down to cavity; basin medium deep and wide, obtuse, with concentric russet lines; calyx deciduous, calyx-cup tightly closed, cork formed in portion immediately connecting to the vascular bundle; core fleshy, distant, medium, closed, core-line clasping; carpel cordate, emarginate, tufted axile-sac; cells symmetrical, axile, smooth; flesh yellowish white, translucent, fine texture, crisp, juicy, slightly acid; flavor medium to sweet; quality fair to good; seeds medium to large, light reddish brown to black, medium plum, acute, long, slightly flattened.

Mi Li

Chinese Meaning	Honey Pear
Species	A hybrid between <i>P. ussuriensis</i> and some other species, possibly <i>P. betulaeifolia</i> (22)
Native	Ma Lan Yi, Peking, China
Distribution	Hopeh, Manchuria, China
Illustration	Plate VI

Size below medium, not uniform, one specimen, 4.8 cm. x 4.7 cm. weighed 67 gm.; shape round oblong to obovate, globular, not uniform; color light greenish yellow, absence of russet, slightly dull; dots numerous, small, light brown, shape irregular, slightly rough; skin smooth, medium thick, somewhat tough; stem long, medium thick, yellowish brown, 3.5 cm. long; cavity medium deep, narrow, acuminate, slightly wrinkled and lipped; basin medium wide to narrow, smooth, deep, obtuse to acuminate, with concentric rings around the calyx-cup; stamen deciduous, core medium, axile, closed, inclined to distant, core-line clasping; carpel ovate, elongated, emarginate, cells symmetrical, smooth, axial-sac tufted; flesh yellowish white, translucent, crisp, fine texture, slightly juicy, gritty near the core, somewhat tender near the skin; flavor neutral, quality fair to good; seeds large, acute, plump, dark red, 1 ng, generally five to six in number, few were undeveloped.

Tzu Ma Li

Chinese Meaning	Sesame Pear
Species	A hybrid of <i>P. ussuriensis</i> and some other species, possibly <i>P. betulaeifolia</i> (22)
Native	Ma Lan Yi, Peking, China
Distribution	Manchuria, China
Illustration	Plate I

Size below medium, one sample 5 x 5 cm. weighed 67.5 gm.; shape obovate to oblate, symmetrical, round, regular; color dull greenish yellow, with russetted marking; dots numerous, variable in size, distributed over entire surface, angular, russet and slightly raised; skin rough, thick, somewhat leathery; stem medium long, curved, 2.5 cm. long, reddish brown to black, medium slender, woody, wrinkled; cavity narrow and shallow, obtuse, furrowed, sometimes wrinkled; basin narrow and very shallow, obtuse; calyx persistent, open, lobes short, erect to recurved, separate at base, acuminate, calyx-tube conical, narrow; stamens persistent, marginal; core medium to small, median, closed, core-line meeting; carpel ovate, emarginate; cells axile, surface smooth, axial-sac tufted; flesh yellowish white, coarse, granular near the core, fairly tender; flavor neutral, somewhat juicy; quality fair; seeds five to eight, few were undeveloped; large acuminate, plump, dark reddish brown.

Conkleton

Species	A hybrid of <i>Pyrus aerotina</i> and <i>P. communis</i>
Native	A seedling of Le Conte, raised in Texas (3)
Distribution	South sections of United States (19)
Illustration	Plate V

Fruit large, fairly uniform in size and shape, globular ovate, obtuse at two ends; color light yellow, some russet markings, sometimes glossy on exposed surface; dots numerous, small, russet, and angular, conspicuous; skin smooth, thin, tender; stem medium long, thick, 1.7 cm. in length, woody; cavity wide, deep, obtuse, patches of russet extending into the cavity over the base, slightly lipped, smooth; basin medium deep, medium wide, obtuse, furrowed; calyx persistent, open, lobes acute, erect, medium long, wide, fleshy and separate at the base; calyx-tube conical, short, medium wide; stamens persistent, median, core medium to large, closed, distant, core-line meeting; carpel ovate-elongate, slightly acute at the top, emarginate, sometimes mucronate; cells axile, symmetrical, smooth, axial-sac tufted; flesh medium coarse, tender, numerous stone cells around the core, slightly juicy, sometimes mealy; flavor slightly sweet, strongly aromatic; quality fair; seeds large, few were undeveloped, reddish brown to black, acute, somewhat flattened and medium long.

Garber

Species	A hybrid of <i>P. serotina</i> and <i>P. communis</i> (10)
Native	Columbia, Pennsylvania (3)
Distribution	South sections of United States (19)
Illustration	Plate VI

Size above medium to large, fairly uniform, one sample 7.6 cm. long, 8 cm. wide weighed 232.5 gm.; shape irregular obvate, flattened at the apex; color dull greenish yellow, sometimes with brownish red strips on the exposed cheek; dots numerous, irregular in size, roundish, russeted, slightly raised; skin slightly rough, thin, tender; stem medium long, medium thick, 2.6 cm. in length, woody, stiff, erect; cavity acuminate, narrow, deep, furrowed and lipped; basin wide, deep, obtuse, somewhat furrowed with concentric wrinkles; calyx persistent, sometimes deciduous, convergent separated at base, variable in size, slender, partly open to wide open, calyx-tube conical, wide, medium deep; stamens persistent, median; core medium to large, median, closed, core-line meeting; carpel ovate, emarginate; cells symmetrical, smooth, axial-sac tufted; flesh yellowish white, granular, large grit cells near the core; crisp but tender, somewhat juicy, neither sweet nor sour but with a peculiar, pleasant flavor; quality fair to medium good; seeds large; few were undeveloped, acute, plump, light brownish black color.

Kieffer

Species	A hybrid of <i>P. serotina</i> and <i>P. communis</i> (10)
Native	Roxborough, Pennsylvania (3)
Distribution	All sections in United States (19); to a limited extent, Tsing Tao, China
Illustration	Plate VII

Size medium to large, one sample 7.1 cm. x 6.8 cm. weighed 201.5 gm.; shape ovate narrowing at both ends, symmetrical, uniform, color yellow, blushed with light red on the exposed cheek, partly russet; dots numerous, conspicuous, light russet, small to large, round to angular, slightly raised; skin slightly rough, thin, medium tough; stem thick, 1 cm. long, woody, tough, stiff, erect; cavity narrow, deeply furrowed, lipped, acuminate; basin narrow, shallow, obtuse, slightly smooth, wrinkled and furrowed, with concentric markings; calyx persistent, lobes opened, wide and separated at base, short, narrow, acute, erect, recurved; calyx-tube conical, medium wide, short; stamens persistent, median; core large, median, closed, core-line clasping; carpel ovate, elliptical, emarginate; cells symmetrical, axile, smooth, axial-sac tufted; flesh yellowish white, slightly granular, tender, juicy, numerous grit cells around the core; flavor very sweet, peculiar and distinctive aroma; quality very good; seeds eight to ten, few undeveloped, dark brown, long, plump, acute, flattened on one side.

Le Conte

Species A hybrid of *Pyrus serotina* and *Pyrus communis* (10)

Native Liberty County, Georgia (3)

Distribution South sections of United States (19)

Illustration Plate VIII

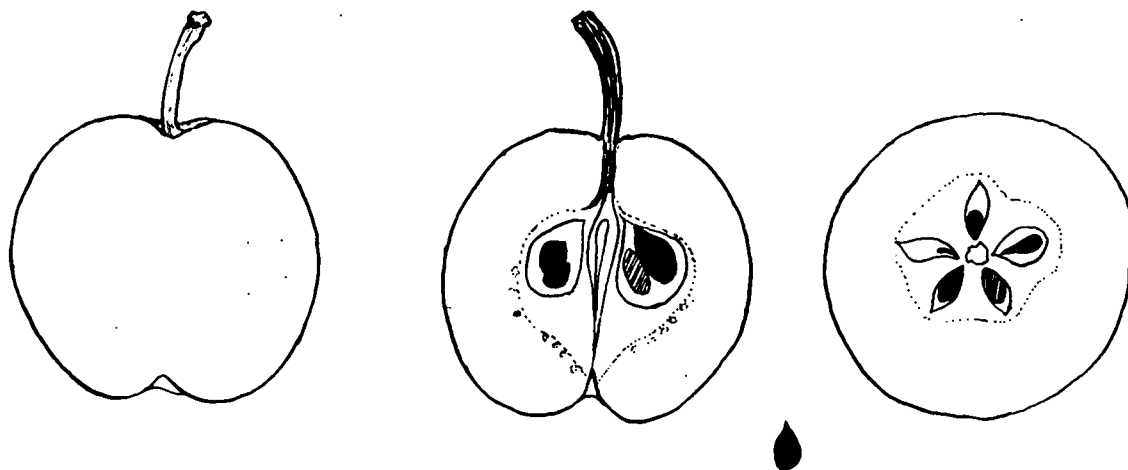
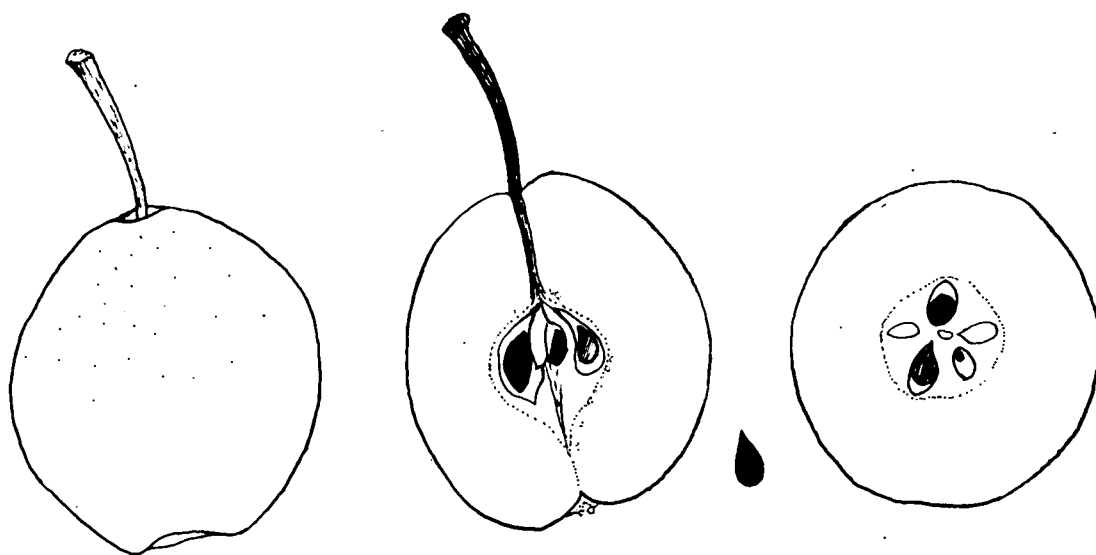
Fruit large, not uniform in size, one sample 7.5 cm. x 8.1 cm. weighed 196.5 gm.; shape oblong ovate, not uniform tapering at both ends with apex wider than the base; color washed greenish yellow, sometimes marked with reddish yellow on the exposed cheek; dots numerous, conspicuous, small, round to angular, slightly raised, light russet; skin smooth, thick, tough, dull yellow, occasionally marked with russet; stem short, 1.5 cm. long, stiff, thick, fleshy, wider at the point of attachment, light brown color, cavity obtuse, shallow, narrow, abrupt, gently furrowed, often compressed; calyx persistent, partly closed, flat convergent; calyx-tube conical, short, medium wide; stamen persistent, basal; core medium, median to distant, closed, axile, surrounded by lines of stone cells, core-line meeting; carpel ovate, emarginate; cells symmetrical, smooth wall, axial-sac tufted; flesh yellowish white, aromatic, dry and mealy when fully ripe, granular, potato-like, grit cells around the core; flavor slightly sweet but flat; quality poor; seeds large, usually two in each cell, few undeveloped brown, wide, plump, acute, two seeds showing germination after six months in cold storage.

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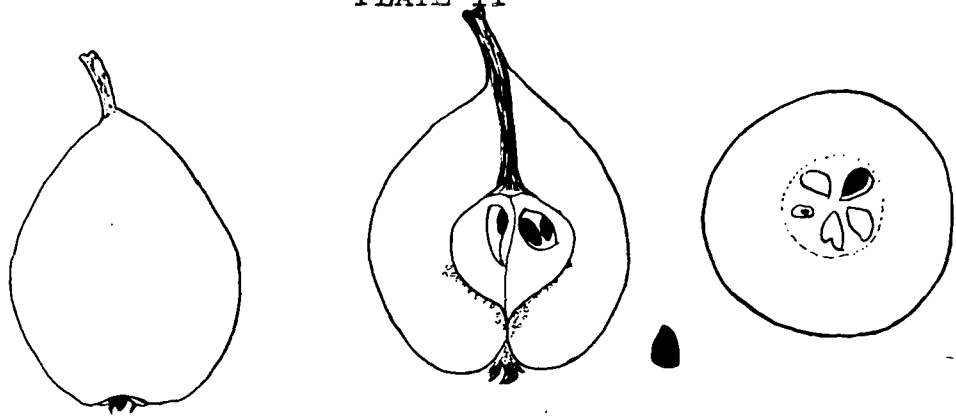
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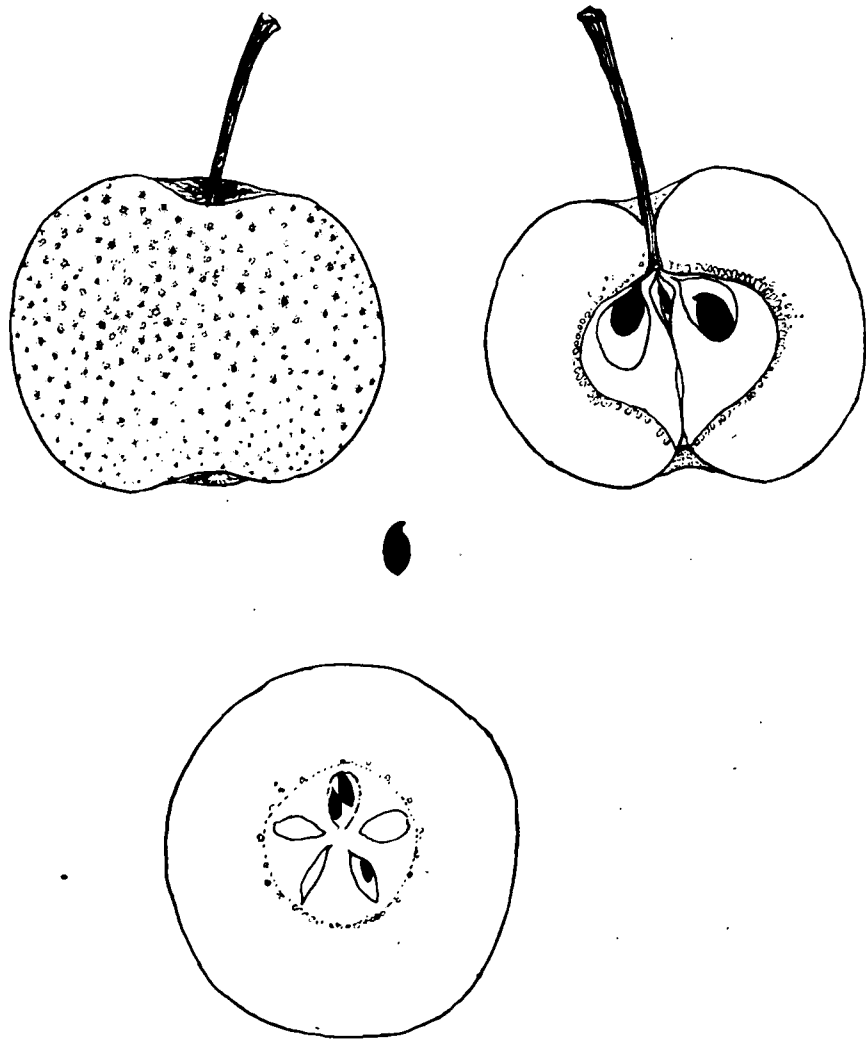
PLATE I

*Hau Kai**Tzu Ma Li*

X 1 1/10



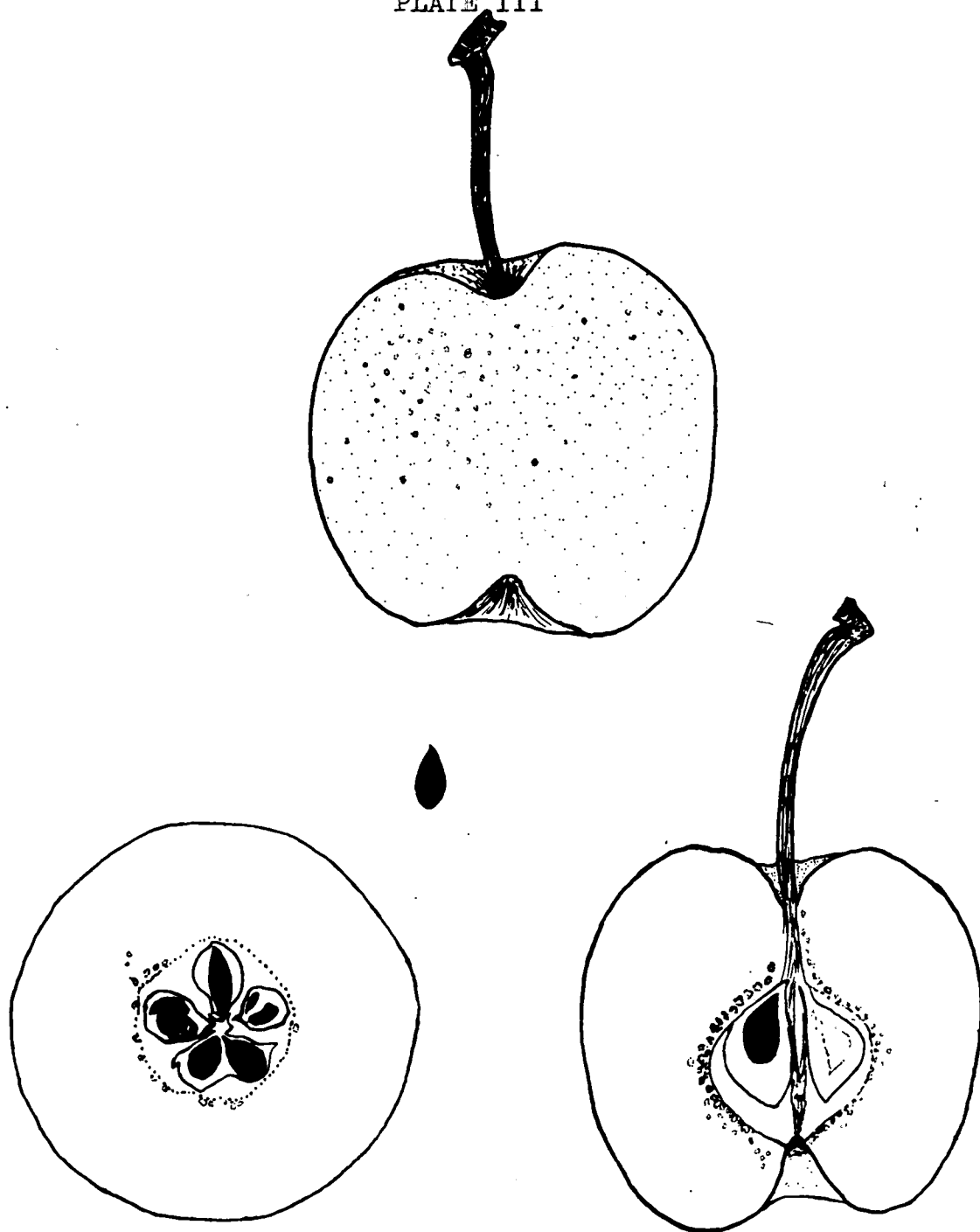
Hsiang Sui Li



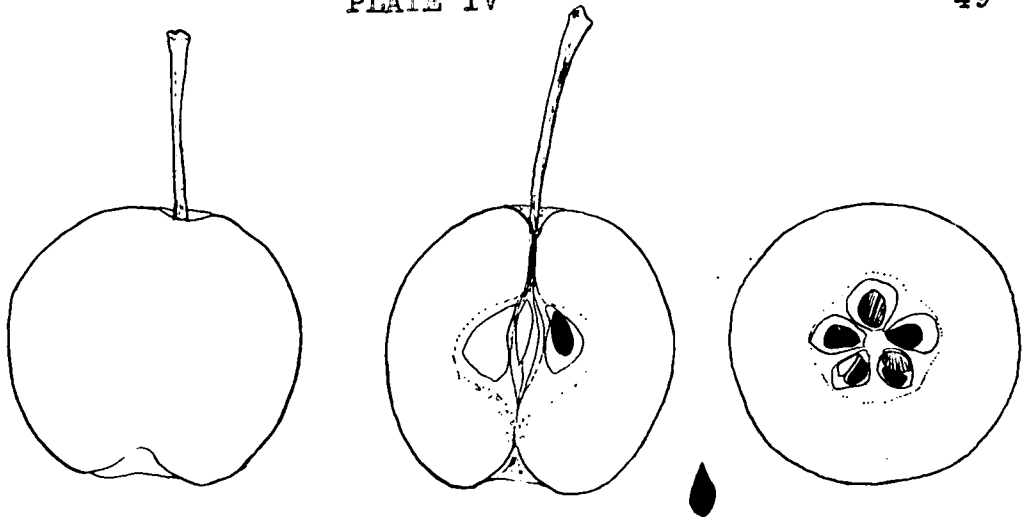
Japan Golden Russet

X 1 1/3

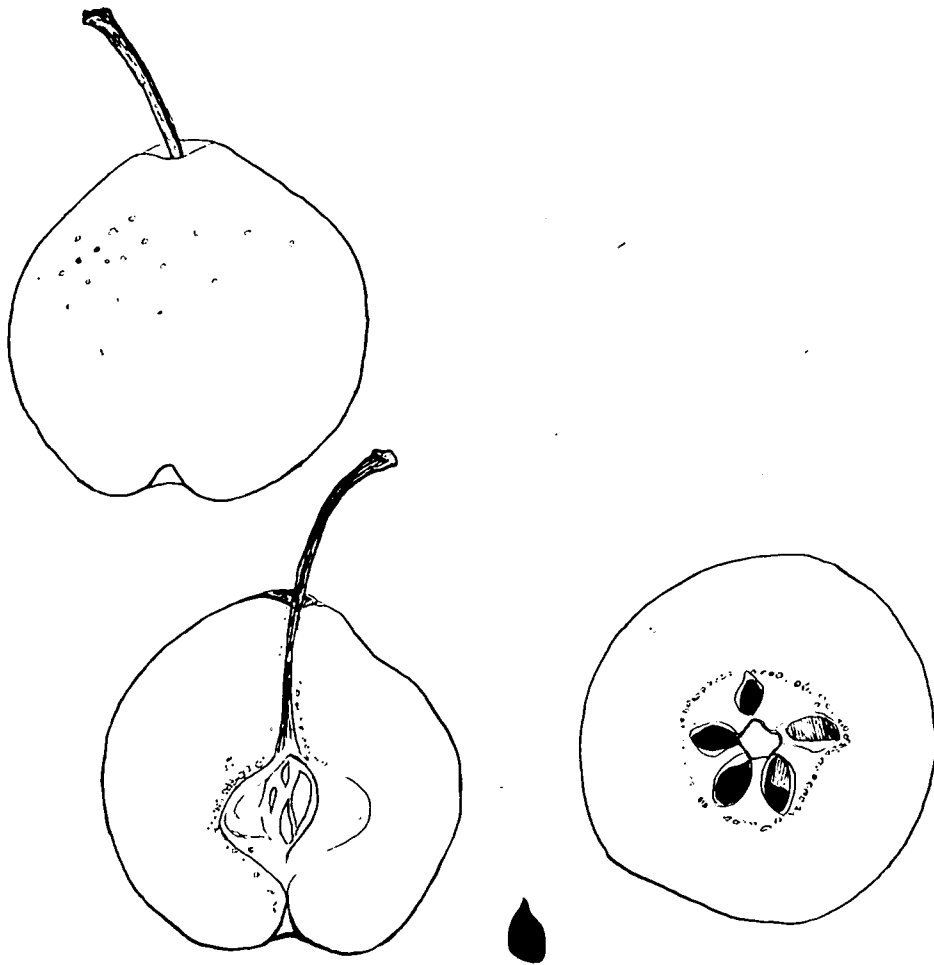
PLATE III

*HUNG LI*

X 95/100



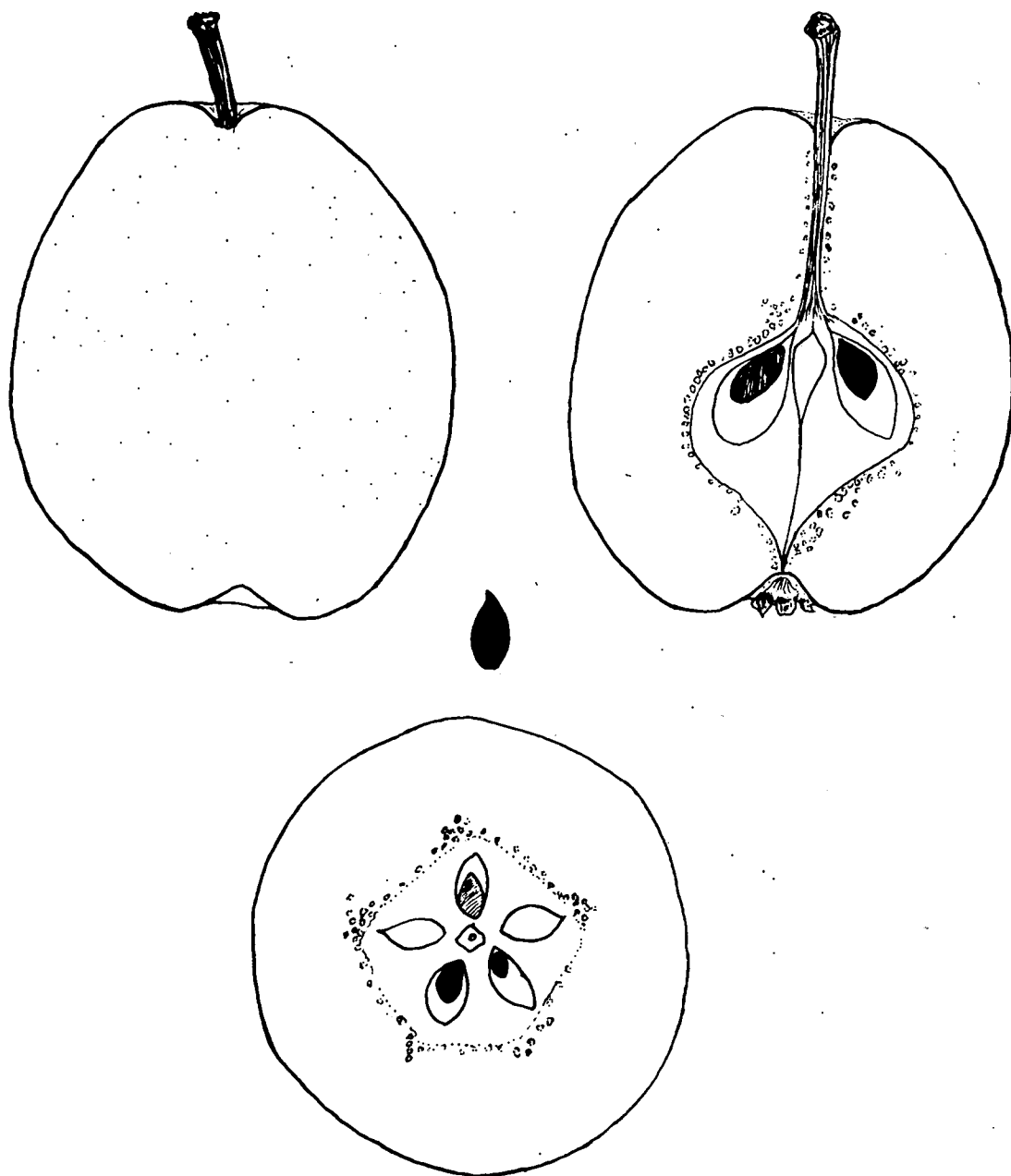
Mi Li



Hung Guar Li

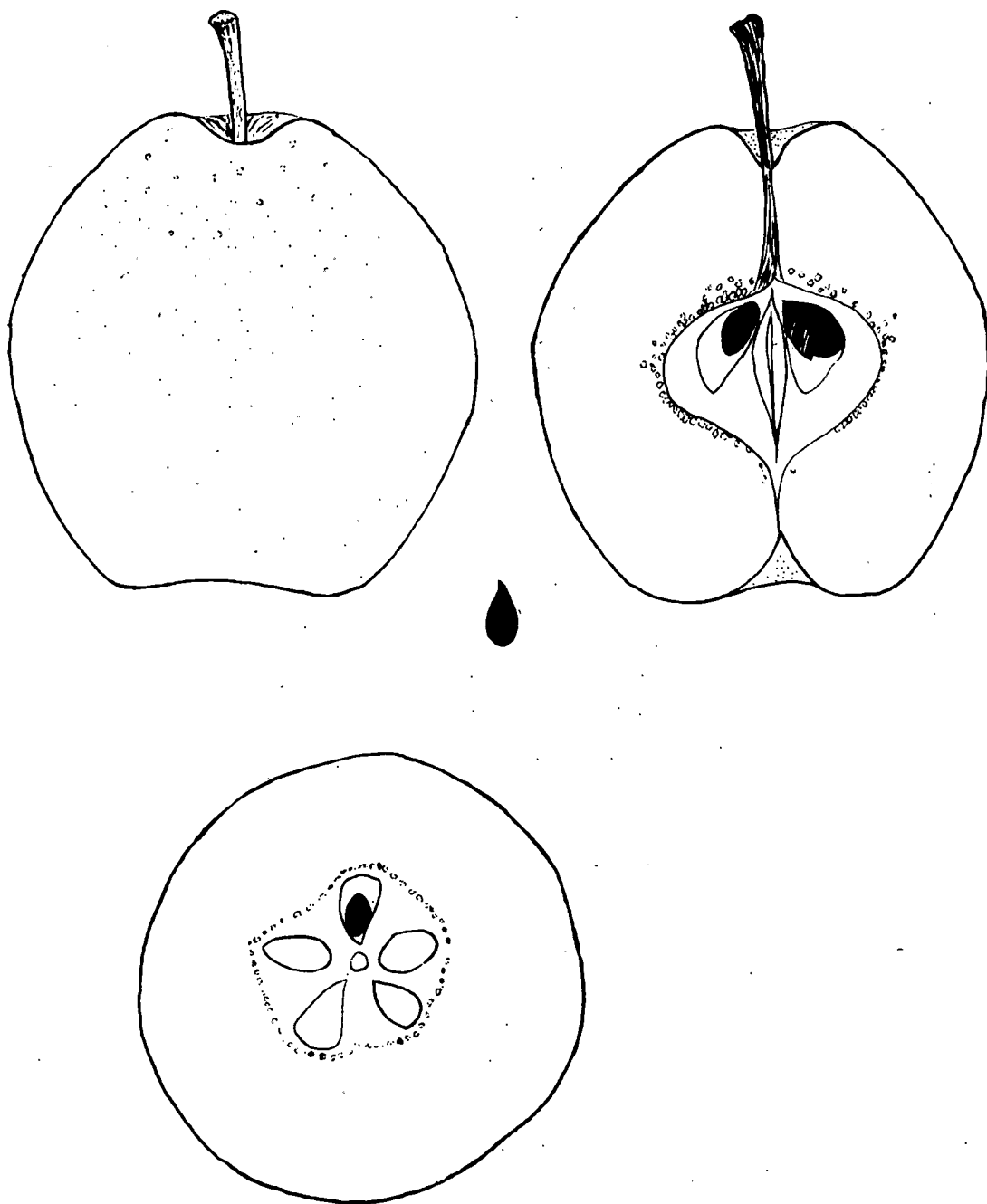
X 1 1/3

PLATE V

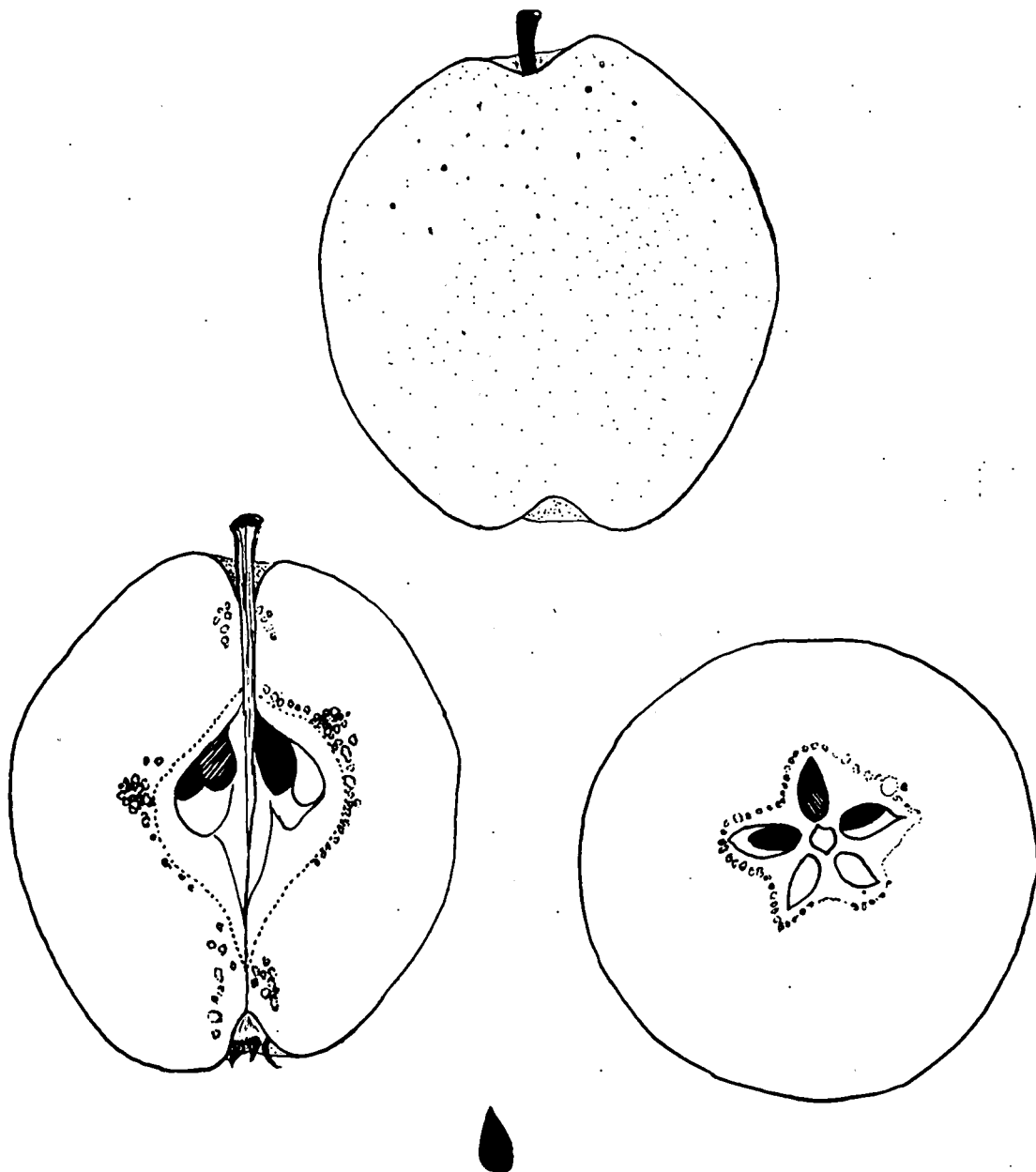
*Conkleton*

X 1 1/10

PLATE VI

*Garben*

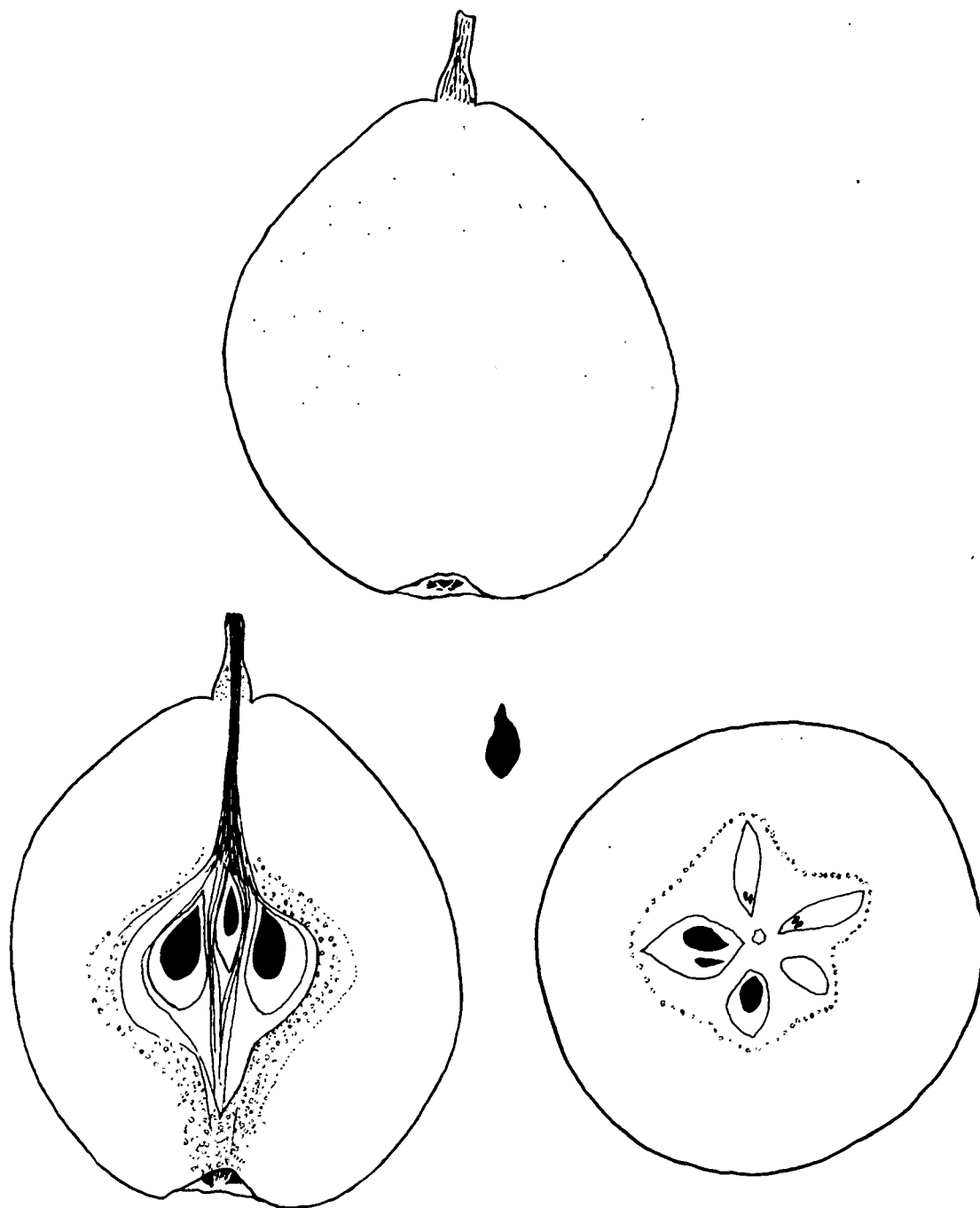
X 1 1/10



Kieffer

X 1 1/10

PLATE VIII

*Le Conte*

X 1 1/10