USOM AGRICULTURAL REPORT

STORAGE PROBLEMS OF DECIDUOUS FRUITS

Report to the Government
of
Israel

Prepared by
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THE UNITED STATES OF AMERICA OPERATIONS MISSION TO ISRAEL

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Excellency:

Presented herewith is a report prepared by Professor Robert M. Smock of Cornell University upon the completion of his thirty-day assignment in Israel this summer. Dr. Smock came here to assist and advise storage operators in proper atmospheric conditions in apple storage so as to prolong the storage season for Israel's increasing apple production. Dr. Smock is one of the world's authorities in the storage of fruit. At Cornell he is primarily occupied with the control of atmospheric conditions in storage to extend the season and preserve the natural qualities of the fruit which goes into storage.

This report is unique in its character; unique in that it is a sort of epilogue to the many conferences which Dr. Smock had with persons engaged in apple storage. Dr. Smock's most important contribution to Israel was in the twenty conferences he had with groups of two to fifteen persons rather than in the report which he prepared. He provided these groups with a great deal of practical information. It is for these groups that this report has been prepared.

Sincerely yours,

Henry Chalfant
Acting Director

His Excellency
Moshe Dayan
Minister of Agriculture
State of Israel

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FOREWORD

My stay involved the thirty day period from July 16 to August 17, 1961. I visited twenty cold storages engaged in the storage of deciduous fruits. The terminal markets in Haifa and Tel Aviv were visited. At each storage, packing house facilities were available but time did not permit more than a cursory study of these. After each storage visit, conferences were held with operators, engineers and interested growers. These numbered from two to twelve persons at each stop. About one dozen orchards were visited and discussions were held with the manager. Five lectures were given. Those in attendance were growers, storage operators, engineers, extension people and research workers.

The stay was very pleasant because of the assistance and cooperation of the personnel here in Israel. I have found the people working in the area of fruit storage to be eager, open minded, understanding and well informed. They have read widely and a number of them have visited abroad. These people "milked me dry".

Especial acknowledgement is due Mr. Jacob Crafin of the Ministry of Agriculture. He arranged part of my itinerary, transported me from place to place, and on a number of occasions housed me in his kibbutz. Mr. Robert Ticho, of the Extension Service of the Ministry of Agriculture, suggested my coming as a request to USOM through the Ministry of Agriculture. Dr. Sylvia Reich, of the Fruit Storage Division of the Agricultural Experiment Station at Rehovot, sponsored my six days of

visiting at that station. Dr. George L. Peterson, Chief of the Agriculture Division of USOM under whose auspices this study was carried out served as general supervisor and provided necessary guidance. I am grateful for their patient tolerance and kindness. The others to whom I am indebted are too numerous to mention.

SUMMARY

1. Even though recommendations have been outlined, it is felt that the most fruitful part of my stay has been the conferences with growers, storage operators, design engineers, and research and extension folks. Exchange of ideas at the personal level has been the most profitable part of this assignment.

2. Fruit maturity studies are needed to evaluate indices of maturity and to determine the best time of picking for storage.

3. The pros and cons of packing before storage are given. The weight of the argument is in favor of packing before storage.

4. The need for packing house efficiency and the danger of over capitalization are stressed.

5. Improved containers for storage are needed.

6. Poly liners are in use but their limitations must be realized.

7. Some country point storages seem over capitalized. Possible economies are pointed out. Precooling of apples before storage seems to have been taken to an extreme. Can the extra expense of 24 hour field heat removal be justified on an economic basis as compared to 72 hour cooling?

8. Ventilation with outside air during storage does not seem necessary.

9. Precautions for good controlled atmosphere operation are given.

10. There is need for study on bitter pit, apple scald, pear scald, and internal breakdown of pears in storage.

11. General recommendations on research and extension are outlined as they pertain to fruit storage.

INTRODUCTION

In 1961 the production of apples will be about 25,000 tons. It is estimated that within 2-3 years this will rise to 40,000 tons. The selling price of apples is presently high but it is inevitable that prices will drop with keener competition in the near future. It is unlikely that Israel can be competitive on the world market in the export business. This raises the question as to what can be done. Possible answers would seem to be:

1. Restrictions on future plantings. This has been done.

2. High yields of high quality fruit with high labor efficiency.

3. Elimination of small, off grade and drop apples from the market.

4. Utilization of off grade and excess fruit by processing. A move has been made in this direction already.

5. Keep packing house and cold storage facilities at minimum possible capitalization.

6. Increasing labor efficiency in the packing house and cold storage.

7. Extend the marketing season of apples and pears through better control of storage diseases and through controlled atmosphere storage.

8. Promotion and advertising to increase sales on the domestic market.

RECOMMENDATIONS

Maturity:

If fruit is to be kept in storage for extended periods with high quality and freedom from storage disorders, it must be picked at the right time. For example, I had a feeling that pears were being packed too ripe for long storage. Over maturity at picking time in pears can cause core breakdown.

The maturity problem is an accentuated one in Israel because of scattered bloom date and hot weather during the harvest period. Israeli growers seem quite aware of the problem. The magnitude of the problem can be visualized by recognition of the necessity of picking a given tree from two to four times and using "stop drop" sprays as much as a month before harvest begins. Such sprays may be applied two times.

Stop drop sprays are a necessity on apples and to a lesser extent on pears. It should be remembered that these sprays stimulate maturation of the fruit on the tree. Minimum dosage rates and numbers of applications should be used on fruits going into storage. Fruits receiving maximum dosages of such sprays should be sold early. All ripe fruit must be kept out of CA storage.

Maturity studies are needed to determine the best picking time for each variety for storage. Maturity indices such as "days from full bloom-related to date of full bloom", pressure test, soluble solids, ground color, size, etc. should be evaluated.

Packing Before or After Storage:

Presently all apples and pears are packed before storage. Growers feel that they cannot afford to pay storage on culls. Many apples and pears are re-sorted and repacked before sale after storage. Sometimes this is done twice.

Advantages of pre-storage packing:

1. Saving in storage space.

2. Culls can move in quantity to a processing plant.

3. The danger of rotten fruit spreading decay in storage is minimized.

Advantages of post-storage packing:

1. Fruit moves from tree to storage faster. Delay means riper fruit. Delays up to 24 hours sometimes occur at present.

2. The buyer gets a fresh pack out of storage without the expense of repacking.

3. The packing house can be smaller.

4. The outlay for grading equipment can be smaller. Fruit is graded out over a period of 6-8 months instead of 30-60 days.

5. The labor force is smaller and can be more skilled.

Someone should study the pros and cons of the above to determine which would be cheaper and better for Israeli growers. A compromise might be to do some pre-sizing and sorting out of decay, etc. before storage without separation into grades.

Packing Houses:

No special study was made of fruit packing houses but observations were made. In general, apples and pears are picked into bulk bins, cartons, or boxes and taken to the packing house. The bulk bins are either on wheels or are transported on trailers and moved with a fork truck. The general handling operation looked good to me. Bin dumping was especially good when the bins were tilt-dumped at the same elevation as the grader. Elevations were causing some bruising when the fruit was "low dumped".

Factors affecting efficiency in the packing house:

1. Minimize equipment investment.

2. Effective use of labor. Considerable waste motion was observed. Simple items such as work stations for ready access to boxes, liners, etc. are important.

3. Minimize materials handling costs. Figure out what new equipment like a fork truck or even a hand operated pallet truck would save in labor costs.

4. Maintain flexibility of arrangement. What equipment will best serve what might be packed in five years?

5. Use floor space economically. Some packing houses looked very large to me.

6. Arrange for employee comfort and convenience. I think this is usually done.

7. Good lighting over sorting and packing areas. The open type sheds do help in this direction. I did see a very few dark sheds with no lighting over the sorting section.

8. Minimize numbers of grades and sizes.

9. Hand placing of pears onto the Jannsen grader seems necessary. It is an expensive operation, however. Hand placing of fruit from the grader into the sales or storage containers seems necessary with any machine. Automatic box or bulk bin fillers are too rough for soft varieties of apples.

10. Will packing be done for 30-60 days or for 6-9 months? Consider labor supply and capital investment in packing house and machinery.

11. If packing out of storage from field run boxes, backlog or accumulate packed boxes in storage for sale. Cartons could take this short backlog period in storage.

12. Study flow patterns in packing house. Plan for straight line flows.

13. Have surge areas along the packing line to eliminate any one person having wasted time.

Containers:

The best container is an ever present problem in all fruit areas. The Bruce box is a standard container for apples and pears in Israel. It uses a minimum amount of wood and is made in the country. It is not an ideal package for storage or shipment of apples and pears. With high piling in storage there is distortion of the bottom boxes from weight. The box has side direction shift when handled. The sides do not have rigidity.

What are the alternatives? One is a semi-permanent, heavy wooden box. This would be picked into and stored field run. It should last 10-20 years. Wooden bulk bins for the future seem more logical. These would be picked into and stored with the fruit field run or possible pre-sized. These bins must be more cheaply constructed than present bulk bins. One proposal was to pick into heavy cartons and fill bulk bins at the packing house for storage. This loses most of the advantage of bulk bins. In small rooms bulk bins would lose space as compared to hand piling. They should have some space as compared to palletizing boxes. Space occupancy should be carefully evaluated before going into bulk bins in storage. In larger rooms (250-300 tons) bulk bins have a more logical application.

Automatic filling of bulk bins at the packing house is being done in the State of Washington. Present fillers seem too rough for soft varieties of apples. Hand filling of bins in the packing house would seem too expensive.

Reasonably priced cartons which will take long time storage with high piling are not presently available.

If the Bruce box is to continue in use, I suggest cooling rate trials on boxes with and without holes in the corrugated liner. These holes should line up with the openings in the Bruce box.

If wooden storage containers are used, the possibility of using cartons as a sales package should be considered. They have many advantages and when properly constructed would have more rigidity in shipment and warehousing than Bruce boxes.

Polyethylene Liners:

Poly liners are being used for pears and for Golden Delicious apples. The present procedure is to pack pears in Bruce boxes with a liner. The top of the box is left open until field heat is removed and then the top of the liner is folded over. This is a rehandling that must be expensive. Ideally, the pears should be precooled (field heat removed) and then packed into poly liners. With packing houses that have cold storages, this could be done. There seems to be concern about the sweating that inevitably takes place. I doubt if the sweating in itself will do any harm but it is true that wet fruit taken over a dirty grader will become quite messy. I suggest a test on the following:

1. No liner and prompt cooling.

2. Field run fruit precooled and then taken over a clean grader (all surfaces clean) and then packed into poly liners.

3. Fruit in liner with top open, precooled and then top folded over (present practice).

4. Fruit packed into poly liner with top of liner folded over and placed into cold storage.

    a. no holes in corrugated liner

    b. holes in corrugated liner.

The cooling rate, labor costs, and final keeping quality should be determined. I suggest this because it is not clear that the present practice can be justified.

There is interest in trying to get a CA effect with sealed liners with pears and perhaps with apples. The hazards of carbon dioxide injury and low oxygen injury are too great. Neither can one analyze each box for its gas levels. Sealed liners with two 60 mm holes at an opening in the box might be tried in order to get a little carbon dioxide effect on pears. Unsealed liners can be justified on Golden Delicious if storage decay is not a problem. Unsealed liners can only give a reduced weight loss effect. On some apple varieties they will aggravate scald.

Pallet covers of .015 inch poly sheets fabricated to fit over a pallet load of apples or pears might be tried. Field heat can be removed and the cover then placed over the pallet load. The hazard is molding of wooden containers and poor weight loss control of the fruit at the bottom of the pallet load. This last is true because the bottom on the pallet load is not covered.

Graders:

The most common machine is the Jannsen. Others are Greefa, Grabill and Cutler. Fruits like the pear must be placed by hand onto the Jannsen. This

is a great labor cost. All of the machines in use except the Greefa drop the fruit out of the sizing mechanism. There is also bruising in the bins. The growers are very cognizant of the grader problem and realize that there is no satisfactory answer to the grader problem for bruise susceptible fruits at the present time.

Roller sorters (rubber covered) are coming into use to give better fruit inspection. Sorting lanes on the roller sorter give greater labor efficiency. My only suggestion is that return flow belts be considered in future installations for the bin sections. They give more flexibility than any type of bins.

Storage:

The first cold storages were constructed in the major cities. Thereafter individual settlements began building their own storages. More recently inter-settlement cooperative storages have been built in the production areas. There are some private storages at country points also. City storage warehouses complain of 44% occupancy. They offer leased space at costs lower than space can be operated at country points. Debate continues on the best location for fruit storages.

Arguments for city storages:

1. Located at point of distribution.

2. Storages were constructed years ago at a lower cost than present construction.

3. Experienced engineer operation around the clock.

4. Packing and repacking facilities are available at many city storages.

5. Greatest hauling distance is only 5-6 hours.

6. Storage rooms can be used for storage of other commodities in the off season.

Arguments for country point cold storages:

1. Cheaper land. More area for truck unloading, etc. Less time lost in traffic jams, etc.

2. Closer to orchards. Fruit is cooled sooner.

3. Settlement labor can pack fruit.

4. Closer supervision of fruit in storage because of personal interest in fruit condition.

5. For CA operation new construction is under way which can provide for gas sealing of floors and eventual complete sealing. City storages would have to convert existing rooms.

Criticisms of Existing Cold Storages:

1. Over capitalization in design. Growers have gone "all out" for rapid field heat removal and for high air volumes during the holding period. There is considerable "gadgetry" around these storages. There are

multiple compressors in many cases. Fast cooling is all ~~the~~ the good but the question is an economic one whether one can justify 24 hour heat removal as compared to 72 hour heat removal with apples. Perhaps one can on pears.

2. Very high air volumes are used during the holding period. Many storages are using 50-60 cubic feet/minute/ton of fruit. Common USA practice would be 10 and not over 20. Two speed motors or some device such as reduced pulley size might be considered. Reduced air volume is a must in CA operation after the field heat is removed. High air velocities aggravate leakage.

3. It seems to be common practice to have the fan operate with the thermostats after field heat removal. It is suggested that trials be made on continuous fan operation (at lower than present speeds) versus intermittent operation to study fruit condition and costs.

4. While indirect cooling with chilled brine may give more even temperatures, the cost is hard to justify with modern refrigeration methods.

5. Some storages have separate compressors for every room. This adds greatly to cost. Two compressors are desirable. They should be "tied together". With back pressure regulator valves, different temperatures can be operated from these two compressors.

6. Ventilation during the holding period is provided in many rooms. This is very hard to justify from an economic point and outside of odor removal is hard to justify from any standpoint.

7. Room size tends to be very small. This is especially true in the country storages. A common figure given for constructing and equipping a country point storage is IL.600/ton fruit. Part of the reason for this high figure is small room size. I saw one recently built cold storage of 4 rooms of 260 tons each which cost IL.310/ton. This storage did not have extra precooling equipment but the fruit was cooled (field heat removal) in place at about a 72 hour rate. The cost difference was partly room size and partly less refrigeration. The savings gained in slightly slower cooling would be in the order of 10% in cost of refrigeration outlay.

The common reasons given for the very small room sizes were:

a. Separation of varieties because of possible ethylene effects.

b. Each settlement wanted a room of its own.

c. Small rooms could be shut down when empty.

My rebuttal to these arguments are as follows:

a. The costs for small rooms are high because of duplication of equipment and construction costs. A more reasonable sized room might be 250-300 tons.

b. It is hard to justify separation of varieties because of possible ethylene effects at 0°C. If one were to take this argument seriously one would have separate rooms for not just varieties but every maturity within each variety. Actually, a ripe lot of Grands could affect preclimacteric Grands more than preclimacteric Jonathans stored in the same room with preclimacteric Grands.

c. Growers can lease a certain number of cubic meters of space in a large room rather than leasing small rooms.

d. Large rooms will be in operation longer, it is true. Yet cooling just the air in a large room is not expensive. If the room is palletized and is only one-fourth full, the fruit can be moved into another one-fourth filled room at less cost than building many small rooms.

e. There is a possible justification for storing pears separate from apples when the quantities are large enough to justify such a practice.

8. Stacking and air distribution

There seems to be a fairly good understanding of the need of good stacking to get proper cooling of the fruit. Air channels between hand stacked boxes or pallet loads should be parallel to the planned direction of air flow from air delivery.

If "precooling" is desired in place in a storage room that is only partially loaded, leakage from around the stack can be prevented by temporarily blocking plenum chambers at the wall, etc. This blocking can be done with cheap material and moved each day as the stack increases in size. Duct arrangements and air delivery in general seemed good. There seemed to be no point in having downward air delivery from the center of the room ducts. The air merely went to the center aisle and thence back to the diffuser without going through the stacks of fruit.

9. Automatic door openers or cold air curtains should be investigated.

10. Corridors seemed very large. In some cases they are used for so called precooling and for re-packing. To the writer the large corridors were not completely justified from an economic standpoint.

Temperature:

Local research has shown 0°C to be an acceptable temperature for apples and pears. One year of research here has shown promise at -1°C for certain apple varieties. Low temperature disorders and freezing damage must be guarded against.

Relative Humidity:

Storage operators seem quite cognizant of the necessity of 90% plus relative humidity. A few undersized evaporators were seen, however. Wetting of the wood of the storage containers seems to be common practice. Some automatic humidifiers were seen but the sensing element in these is seldom accurate enough to operate the equipment.

Controlled Atmosphere Storage:

One kibbutz has experimented privately on CA storage of apples and pears and has 13 CA rooms in operation. The Israel Fruit Growers Association started small scale experiments in 1959. I ate some excellent Grand Alexander (probably the variety Calville de St. Sauvier) in late July of 1961 from CA storage. Information on the proper atmospheres and temperatures is still not publicly available. Interest is shown in the commercial CA storage of Grand Alexander, Rome Beauty, Jonathan apples and Spadona and Coscia pears.

Every effort must be made to construct successful CA rooms. Precautions must be taken to keep moisture out of the walls and ceilings. American experience has shown that high grade expanded polystyrene was superior to corkboard in resisting moisture pick-up.

Every effort must be made to make the rooms gas-tight. Operators cannot economically justify compensating for leaks by the use of nitrogen gas.

The following precautions are proposed:

1. Make the room as large as is feasible.
2. Test the room for leaks under air pressure.
3. Insure good workmanship throughout.
4. Use outside vented water drains from the diffuser defrost system.
5. Seal all electrical conduits inside the room.

6. Have the room as full of fruit as possible without interfering with air distribution.
7. Use reasonable air volumes after the room is sealed.

On small rooms, dry lime may be the best approach to the carbon dioxide removal problem. For larger rooms water scrubbing seems feasible. Some salt will be required, so use corrosion resistant equipment.

Only the consumer can decide what volumes of apples and pears should be in CA storage and how long they should be kept (assuming they are in good condition). Avoid saturating the market at any time.

Storage Disorders:

Work should continue on the use of calcium nitrate to try to control bitter pit in Grand Alexander. Calcium nitrate treatments will probably never completely control bitter pit. Attention must still be paid to:

a. Avoiding over fertilization with nitrogen
b. Avoiding picking in an immature stage
c. Avoiding over pruning and thinning (this damage does not seem likely in Israel in the immediate future)
d. Storing promptly, cool fast and keep a high relative humidity in the storage.

Scald is a real problem on Grand Alexander. Scald control trials should continue with diphenylamine and Stop Scald. How long the Stop Scald emulsion can be used without changing should be studied in packing houses. Methods of application of Stop Scald have been outlined in detail with growers.

Pear scald might be studied with a comparison of Stop Scald and oiled paper wraps versus controls. Yellowing with Stop Scald should be watched for.

Watching Condition in Storage:

Loss of condition of fruit in storage should be anticipated by storage operators. It is inexcusable to lose a room full of fruit from scald. Test samples should be removed at weekly intervals after mid-November to evaluate scald, pit, and loss of firmness. The holding period for these samples should be two weeks at around 20-25°C. Scald can also be predicted as to intensity by holding samples in unsealed poly liners for 6 weeks at 20-25°C after harvest. This method underestimates the scald that will occur in cold storage but the procedure is useful.

GENERAL RECOMMENDATIONS

It is somewhat hazardous for a short term visitor to make recommendations on too broad a scale. The writer also recognizes that the Israeli visitor to the USA can see the flaws in our operational procedures.

1. Research, extension and education should be completely integrated as soon as possible. There is some integration already but in some cases there is duplication in research, etc.

2. I would like to see the status of the extension worker elevated. He is now somewhat of a "second class citizen". He should be encouraged to do some research, particularly at the applied level. He must know whereof he speaks when he talks to growers. He must have the respect of the industry. Extension men are spread "too thin". It is impossible in modern fruit culture and storage for one man to know everything. Why not have an extension man become a "specialist" in topics such as entomology, pathology, nutrition, storage and handling, etc? In this way the extension man can command the respect of growers. Farmers expect and deserve expert knowledge.

3. Growers seem to feel that research is in an "ivory tower" and not interested in their practical problems. I do not think this is completely true but the feeling must be dispelled from the minds of the grower. Farmers state, and rightly so, that the function of an agricultural experiment station is to serve farmers and not to enhance the prestige of staff members. Farmers will beat a path to the doors of research people

when they know they can get answers to their pressing, practical problems. As it stands, they do private research to try to get "quick" answers.

4. Research in the field of storage of fruit is highly fragmented. Research is done by different groups, different people within groups and in different places. Individual settlements, The Israel Fruit Growers Federation, The Agricultural Experiment Station (more recently), and Extension staff are doing "research" on fruit storage. The Federation has research staff and a well equipped experimental set-up for cold and CA storage investigations. No one person supervises this research, however. It is scattered among four storages.

An adequate cold and CA storage research facility is urgently needed at Rehovot for deciduous fruits. If facilities are not forthcoming, any attempt at research might as well be forgotten. If good facilities are provided and if good work is done, there should be no need of private research.

I would visualize an extension man whose speciality is storage and handling of deciduous fruits. He should be closely associated with the person at Rehovot doing research full time. He should be allowed to conduct some trials of his own. For example, he could do bitter pit trials in growers' orchards and store test samples in settlement storages. He could supervise scald control trials around the storages of the country, etc. I do not like to dissociate research from extension either. I would visualize the full time research person doing some extension work to report

on research findings to grower groups, etc. The research person should never lose sight of the practical problems of growers.

5. I am impressed with the present necessity of research workers having to buy fruit for experimental work. Many experiments require large numbers of fruits and research workers should not be limited in their work by budget for fruit. Perhaps growers can donate fruit cooperatively.