TID 17886
Isotopes-Industrial Technology
TID 4500(19th Ed.)

ECONOMIC FEASIBILITY OF RADIATION-PASTEURIZING

- fresh strawberries,
- peaches,
- tomatoes,
- grapes,
- oranges,
- and grapefruit

PREPARED BY UNITED STATES DEPARTMENT OF AGRICULTURE
Economic Research Service
Marketing Economics Division
Washington 25, D. C.

FOR UNITED STATES ATOMIC ENERGY COMMISSION
Division of Isotopes Development

This report was prepared for the Division of Isotopes Development of the United States Atomic Energy Commission by the United States Department of Agriculture, under contract No. AT (49-11-2085)

LEGAL NOTICE

Printed in USA. Price $0.75. Available from the Office of Technical Services, Department of Commerce, Washington 25, D.C.

PREFACE

This report is the first of a group on the economic feasibility of pasteurizing selected fresh produce by ionizing radiation. The study was conducted by the U.S. Department of Agriculture for the Division of Isotopes Development of the U.S. Atomic Energy Commission. It contains the results of a survey of the produce industry on the feasibility of radiation-pasteurizing fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit.

Additional research is planned to develop information needed to complete the analysis of economic feasibility of processing and marketing selected radiation-pasteurized fruits and vegetables. Needed information includes estimates of: (1) comparative costs and benefits of radiation processing relative to other processes currently in use, and (2) the probable effect of radiation processing on prices, supplies, and the market structure of the selected commodities.

Robert H. Reed participated in planning the research and served as supervisor. Alfred J. Burns, Floyd W. Williams, Donald G. Gillette, and Melvin B. Allen assisted with the survey work. The author is indebted to the Market Quality Research Division, Agricultural Marketing Service, and the Standards and Research Division, Statistical Reporting Service, for many helpful suggestions. In addition, thanks are expressed to Dr. Kevin G. Shea, Division of Isotopes Development, U.S. Atomic Energy Commission, Mr. A. L. Morel, Bureau of Commercial Fisheries, U.S. Department of the Interior, and Captain George R. Dietz, U.S. Army Quartermaster Research and Engineering Command for technical information, helpful suggestions, and review of the manuscript.

CONTENTS

August 1963

SUMMARY

Ionizing radiation pasteurization is a method that might be used to extend the cold storage life of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit.

In a survey conducted for the Atomic Energy Commission during the summer of 1962, fresh produce handlers were asked to state their opinions and judgments about the merits of the method.

Prior to interviewing, respondents were sent information and then were briefed about radiation processing so that answers to survey questions might be more meaningful and useful. Briefing was necessary because the new process has been used only in research and is not available commercially.

Among the advantages expected of radiation pasteurization, the two most often given by respondents are that it would (1) reduce spoilage losses, and (2) maintain quality. Among the disadvantages expected, the one most often given is consumer resistance due to fear of the process. Two other disadvantages often given are that it would (1) require an extensive educational program, and (2) increase processing costs.

A high percentage of respondents thought successful market introduction of radiation-pasteurized fruits and vegetables would depend on an effective educational or promotional program. The purpose of the program would be (1) to acquaint consumers with the new process, (2) to inform them of its potential value, and (3) to assure them that radiation-pasteurized fruits and vegetables are completely safe for human consumption.

A majority of the respondents thought that radiation processing would increase the production and market volume of the selected fresh fruits and vegetables surveyed, but would not change output and sales volume of canned, frozen, and other processed forms. A minority of the respondents thought the new process would reduce output and sales volume of canned, frozen, and other processed forms of the selected commodities.

The desired extensions of refrigerated storage life and the cost that respondents thought they could afford to pay for radiation pasteurizing are summarized below:

Commodity	Average extension of refrigerated storage life	Estimated cost respondents could pay for radiation processing[1]
	Days	Cents per pound
Strawberries	8.2	1.75
Peaches	14.1	.25
Tomatoes	16.4	.25
Grapes	22.6	.25
Oranges	10.7	.25
Grapefruit	9.8	.25

[1] Midpoint of the one-half cent modal class interval when zero responses are not considered.

A packinghouse or shipping point was selected as the most appropriate location for radiation processing, and except for strawberries, a small stationary radiation facility for each handler was thought to be the best for processing the selected commodities. For strawberries, a large centrally located facility and a mobile facility were each reported by one-third of the respondents as the most appropriate facility. Only one-sixth of the respondents handling strawberries thought a small stationary facility was needed.

Most respondents thought only minor changes in present methods of handling produce would be required to accommodate radiation processing. However, about half of the few who preferred a large, centrally located facility thought substantial changes in present handling methods would be required.

ECONOMIC FEASIBILITY OF RADIATION-PASTEURIZING FRESH STRAWBERRIES, PEACHES, TOMATOES, GRAPES, ORANGES, AND GRAPEFRUIT

By John H. Droge, agricultural economist
Marketing Economics Division
Economic Research Service

INTRODUCTION

Much effort has been expended to find a method of preserving perishable food in a condition closely approximating its natural fresh qualities. Several processes including canning, freezing, drying, and freeze-drying have been developed but all involve some changes in the physical characteristics of fresh perishable foods.

Two commonly recognized and closely related problems in handling and marketing fresh produce are (1) high spoilage losses, and (2) short shelf life. Annual average after-harvest spoilage losses expressed as a percent of retail value during 1957-61 were estimated for five commodities as follows:[1]

Commodity	Marketing spoilage loss as percent of retail value*
	Percent
Strawberries	15.0
Peaches	9.0
Tomatoes, bulk	16.0
Grapes	10.9
Oranges	1.6

*Estimated losses due to: (1) total spoilage requiring items to be discarded, and (2) partial spoilage requiring reduction in retail prices.

Low-dose ionizing radiation pasteurization appears promising as a method of reducing spoilage and extending shelf life while retaining natural fresh qualities. Intensive research indicates that the radiation process produces a partially sterilized product with superior keeping qualities if protected from reinfestation with spoilage-causing organisms.

Wholesomeness research sponsored by the U.S. Army Quartermaster Research and Engineering Command has shown that irradiated food is safe for human consumption.[2] Additional research has shown that low-dose radiation pasteurization has very little, if any, effect on vitamins, pigments, pectins, collulose, and starch in perishable foods.

---

[1] Unpublished estimates of the Market Quality Research Division, Agricultural Marketing Service, U.S. Department of Agriculture.

[2] Further proof of the safety of the process was indicated in February 1963, when the Food and Drug Administration cleared radiation-sterilized bacon in its first irradiated-food petition. Under the Food, Drug, and Cosmetic Act, it is necessary to submit a food additive petition for any use of radiation in either sterilization or pasteurization of foods if such use is not covered by specific regulations.

Radiation preservation of perishable food is considered by food technologists in terms of two dose levels corresponding with long-term and short-term storage capabilities:

1. A high-dose sterilizing level, greater than 1 million rads and usually in the range of 2.0 to 4.5 million rads, provides a capability for long-term storage without refrigeration, and
2. A low-dose pasteurizing level, 1 million rads or less (usually around 200,000 rads for fresh fruit), provides a capability for extending short-term storage under refrigeration.

Technical research has progressed to a point where an evaluation of the economic feasibility of this new process is needed. To develop this objective requires information on (1) trade and consumer acceptance; (2) costs and benefits of radiation processing compared to other processes currently in use; and (3) the probable effect of radiation processing on prices, supplies, and market structure of commodities considered. The opinion survey described in this report is a first step in determining the economic feasibility of pasteurizing selected fresh produce with radiation.

Preliminary estimates were obtained for fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit.[3] Growers, shippers, wholesalers, and chainstore produce managers were asked for their opinions about:

1. Expected produce industry and consumer reaction.
2. Expected advantages and disadvantages of the process.
3. Costs for the process that might be absorbed by the market system.
4. Extension of refrigerated storage life needed for each commodity.
5. Expected effect on market volume.
6. Size, type, and location of radiation processing facilities needed.

Other research is planned to develop additional information needed to complete the analysis of economic feasibility of processing and marketing selected radiation pasteurized fruits and vegetables.

THE SAMPLE

A sample of 306 relatively large fresh produce firms was selected as follows: (1) 171 growers and shippers were selected from among firms with an annual volume of 100 carloads or more, and (2) 135 firms at other levels in the marketing channel from among those handling an annual volume of 200 carloads or more.[4] Alternate firms were selected and were used as replacements when sample firms could not be interviewed during the time field interviewing was planned for their production area or market city.

Growers and shippers in the sample comprised about 20 percent of the larger firms located in 10 major producing States for the six commodities considered (appendix A, table 3).[5] These States accounted for 71 to 98 percent of U.S. annual average 1954-58 production of the selected fruits and vegetables (appendix A, table 4).

Produce wholesale firms and chainstores included 35 firms in Boston, 46 in Chicago, and 54 in New York (appendix A, table 6). These cities were selected because they are major market areas with relatively long lengths of haul from the important producing States for the commodities being studied.

PERSONAL INTERVIEWING PROCEDURE

A letter was sent to prospective respondents about 2 weeks before they were contacted for interviewing. It asked for their cooperation in the survey and included a brief explanation of radiation pasteurizing, together with laboratory research findings when the process was applied to some of the fruits in the survey (appendix B).

The interviews were conducted by staff members experienced in fruit and vegetable marketing research. Before the interview, general characteristics of radiation pasteurizing were discussed with each respondent, and the enumerator answered questions asked about the process.

---

[3] The research procedures were similar to those of an earlier study, "Marketing Feasibility Study of Radiation Processed Fishery Products," U.S. Atomic Energy Commission, WASH 1030, December 1960.

[4] The sample was selected from firms listed in The Blue Book, A Credit and Marketing Guide for Wholesale Handlers and Users of Perishable Fresh Fruits and Vegetables in the U.S. and Canada, published semiannually by the Produce Reporter Company, Wheaton, Ill.

[5] Tables 3 to 16 are in appendix A.

SURVEY RESULTS

Answers to survey questions reflect the marketing experience and opinions of 306 respondents (171 growers and shippers, 111 produce wholesalers, and 24 chainstore produce managers). Each respondent handled one or more of the six commodities. On a commodity basis, the number of respondents having handling experience are: Strawberries 112, peaches 164, tomatoes 141, grapes 112, oranges 131, and grapefruit 116.

In addition to the tabulated answers, representative comments were selected and quoted to convey as closely as possible both the content and meaning of the numerous comments received in reply to the survey questions presented below.[6] The quoted comments may duplicate each other in a general sense; however, they are given as they were made.

Question 1.--What might be the general reaction from the produce industry regarding radiation pasteurization of fresh fruits and vegetables?

Survey answers for all respondents were:

	Percent
Favorable	68
Unfavorable	13
No conclusion or comment	19

Percentages of favorage answers by marketing function performed are:

	Percent
Growers and shippers	73
Wholesalers	60
Chainstore produce managers	71

The lower percentage of wholesalers responding favorably to this question could be linked to their evaluation of the effect of the process on sales volumes. A number of wholesalers thought radiation processing would lower their sales volume because spoilage would be reduced and then less total volume would be required to supply the market.

The following comments contain the main ideas in the survey answers to question 1.

Unfavorable:

1. "Scared of process."
2. "Process is too expensive at present."
3. "Cannot justify because produce keeps well enough now."
4. "Industry should react violently to this process. It would result in lower prices. There is a surplus of fresh vegetables now and spoilage is a blessing."

Favorable:

1. "Assuming the process could be applied without material change in color, flavor, quality, etc., at a reasonable cost and with Government approval, then I think the industry would welcome it."
2. "If proven safe for human consumption, industry would welcome it because it is always looking for ways to upgrade quality and appearance of products placed on the market."
3. "Could allow more fresh marketing and extend fresh marketing season."
4. "The process would help to regain some of the market lost to processed."

[6] Those interested in more details are referred to the tables in appendix A.

Question 2. --What might be the general reaction from consumers regarding radiation pasteurized fresh fruits and vegetables?

Three out of five respondents interviewed thought consumer reaction would be favorable, one out of five thought it would be unfavorable, and the other one out of five did not give a usable answer.

Percentages of favorable answers by marketing function performed are:

	Percent
Growers and shippers	63
Wholesalers	51
Chainstore produce managers	79

Chainstore produce managers are more optimistic about the process than growers, shippers, and wholesalers. This could be of special interest since they are only one step removed from consumers and presumably are in a better position to estimate consumer behavior.

The following comments represent answers to question 2.

Unfavorable:

1. "Would be scared at the beginning because of publicity of fall-out and radiation danger."
2. "Consumers will react unfavorably unless they are well informed about the safety of it."

Favorable:

1. "If it prolongs shelf life and gives consumers everything they now have together with no harmful effects, they would welcome it."
2. "The public is not interested in how you preserve or keep it, but in how it looks and tastes."
3. "The Americans accept anything that the Food and Drug Administration approves. People in foreign countries would be more reluctant."
4. "No objection if fruit is of good quality and consumers are informed."
5. "With proper education, I think it would be acceptable."
6. "Should please consumers to get good quality fruit over a longer period of time."

In answering question 2, 49 percent of the growers and shippers, 30 percent of the wholesalers, and 58 percent of the chainstore produce managers indicated without being asked that they thought an educational or promotional program would be required. They thought the program would be essential (1) to acquaint consumers with the radiation process, (2) to inform them of its potential value, and (3) to assure them that radiation-pasteurized fruits and vegetables are completely safe for human consumption.

Most respondents who gave comments regarding labeling thought a label designation referring directly to radiation pasteurization would scare consumers unless and effective educational or promotional program was first completed. Others thought quality, appearance, and storability were the only important factors in selling produce, and if any one of these factors were improved produce sales would increase.

Responses to questions 1 and 2 indicate that produce handlers expect the produce industry to be more receptive than consumers to radiation-pasteurized fruits and vegetables.

Question 3. --What advantages might come from radiation pasteurization of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

The two advantages most often reported by respondents are:

1. "Would reduce spoilage loss."
2. "Would maintain quality."

Other advantages often mentioned are:

1. "Expand established markets."
2. "Tend to stabilize markets."
3. "Lengthen market season."
4. "Facilitate distribution."
5. "Result in improved merchandising methods."
6. "Develop new markets."

Advantages mentioned less frequently are:

1. "Reduce costs of handling and transportation."
2. "Can ship longer distances."
3. "Would be a benefit to exporting."
4. "Can harvest in a more ripened and better flavored condition."
5. "Enable to ship and sell a more mature fruit."
6. "Will increase prepackaging at shipping point."
7. "Will increase per capita consumption."
8. "Will result in better satisfied customers."
9. "Suppliers would be able to buy more efficiently."

From 5 to 11 percent of the respondents thought there would be no advantage to the process.

Question 4. --What disadvantages might come from radiation pasteurization of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

The disadvantage most often reported by respondents is consumer resistance due to fear of the process (appendix A, table 11). Two other disadvantages often reported are:

1. "It would require an extensive educational program."
2. "Would increase processing costs."

Disadvantages mentioned less frequently are:

1. "Would increase surplus or market supplies and depress prices."
2. "Some areas would lose their seasonal advantage."
3. "Would drive tomato repackers out of business."
4. "Less volume would be handled."
5. "Would put middle men out of business."
6. "Would reduce the number of growers and shippers because of higher investment requirements."
7. "The radiation processing facility would be bulky."
8. "May require slowing down production lines."
9. "Danger to employees while processing."
10. "Possible loss in fruit and vegetable color, flavor, etc., resulting from the process.

Questions 5. --From a marketing and consumer viewpoint, what would be the most desired number of days extension of refrigerated storage life from radiation pasteurization of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

Increases in refrigerated storage life ranging from 8.2 to 22.6 days are indicated by commodity response averages of survey answers for the six commodities studied (table 1 and appendix A, table 11).

TABLE 1.--Days of additional storage life respondents wanted for 6 commodities[1]

Item	Strawberries	Peaches	Tomatoes	Grapes	Oranges	Grapefruit
	Days	Days	Days	Days	Days	Days
Average.....	8.2	14.1	16.4	22.6	10.7	9.8
Range.....	0-270	0-270	0-270	0-195	0-75	0-75
Number of responses..	66	101	90	62	92	78

[1] Range of replies giving a specific length of time (excludes such replies as "as long as possible").

Comments reflecting the ideas of respondents concerning extended refrigerated storage life are as follows:

1. "No need to extend storage life, but the process would be valuable for reducing spoilage and maintaining quality."
2. "If storage life were extended it would benefit other production areas relatively more which would be to our (California's) detriment."
3. "When market is good no extension is needed; when market is bad we need another week or two."
4. "No extended life needed until at end of season. For peaches, better quality fruit comes later in the season; therefore, no benefit from storing early production."
5. "If storage life is extended, we can distribute product more evenly and avoid marketing too much at times of overproduction."
6. "Extension of shelf life would be extremely beneficial."
7. "Extended storage life is needed for export sales."
8. "Extend storage life as much as possible without loss of flavor, quality and appearance."
9. "The longer storage life can be extended the better."

Question 6. --On the basis of your judgment with regard to the advantages and disadvantages of radiation processing, what is your best estimate of the cost you could afford to pay for radiation pasteurization of strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

Most respondents gave estimates in terms of a range of costs rather than a single figure. The range of cost estimates and the modal class cost interval for each commitity are given in table 2.

The question was difficult to answer because of (1) the limited information available about the process, and (2) the amount of projection and judgment required in answering it. Considered by commodity, approximately one-half of the respondents in each case did not answer question 6. Those who did answer it gave a wide range of cost estimates (table 2 and appendix A, table 12).

TABLE 2.--Cost per pound that respondents estimated they could pay for radiation processing of 6 commodities

Item	Straw-berries	Peaches	Tomatoes	Grapes	Oranges	Grape-fruit
	Cents	Cents	Cents	Cents	Cents	Cents
Range of cost estimates..	0-6	0-3	0-4	0-3	0-3	0-3
Modal class.....	1-1/2-2	0-1/2	0-1/2	0-1/2	0-1/2	0-1/2
Number of responses.....	59	81	64	53	71	59

Until better information can be provided, these answers are expected to be of considerable value as preliminary estimates of costs that might be paid to radiation-pasteurize the commodities involved. They can give persons charged with research and development planning the benefit of the opinions and judgments of produce industry personnel who handle the selected commodities.

The following comments reflect some of the assumptions made by the respondents in estimating the costs summarized in table 2.

1. "Need more information on costs of process and on potential benefits throughout market channel. Give us better estimates on the economies and on the quality improvements, then we can determine what we can pay."
2. "What the market system could pay depends on how much spoilage is saved and the price received for the commodity."
3. "If retail price dropped as a result of longer supply of a more durable product, market would not absorb any increase in processing costs. Would then result in shipper and grower accepting a reduced margin."
4. "The housewife will not be willing to pay any more if she can continue to buy good produce at lower prices. Overall market would not absorb any price increase."
5. "Could replace cost now paid for spoilage inhibitors."
6. "Any increase in cost would likely be offset by reduction in losses through spoilage so that consumer prices would not have to be increased. If it cost the consumer more money it would not be acceptable."
7. "Market is too variable to say what it will absorb; weather factors have a great influence. Market would likely absorb some increase in price, but could not say how much."
8. "The industry is always interested in putting a better product on the market and is willing to pay to get it if proven to be beneficial at a feasible cost level."
9. "If it provides a better product, the market automatically will pay for its added cost and maybe up to three times that amount."
10. "So far, experience in the shipping of produce indicates that the cost of new practices cannot be passed on to our buyers, but retailers and others at that end of the market can get a higher price for the improved produce."

Question 7.--If radiation pasteurization is proved to be commercially feasible and is adopted by the produce industry, how might it affect the production and marketing of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

No substantial difference in responses was noted among commodities. Survey responses for all commodities combined are as follows (appendix A, table 13):

	Percent of respondents
Increase volume	47
Decrease volume	8
No change in volume	14
Do not know or no answer	31

By marketing function performed, percentages of respondents estimating increased production and marketing volume are: growers and shippers 57, wholesalers 28, and chainstore produce managers 79 percent. Wholesalers represent the lowest percentage, but this could be attributed mainly to the fact that about 50 percent of them did not answer the question. For comparison, about 25 percent of the growers and shippers and 5 percent of the chainstore produce managers did not answer.

Numerous comments were received concerning the possible effect of radiation pasteurization on production and market volume, and on production and marketing practices for the selected commodities. These comments were typical:

1. "The grower would not be interested because the process would create surplus by increasing consumable supply. It would reduce the volume handled by commission merchants

and others in the marketing channel. The process would be good for retailers and consumers, but bad for others."

2. "Less will be consumed as consumers will stay clear of irradiated produce."

3. "If a proper educational program were put into effect, it should increase sales."

4. "If the process is approved by the Government, then tree-ripened fruit would be marketed. The housewife and public would appreciate a tree-ripened, better flavored fruit and they would buy more."

5. "Would improve grower returns because higher prices would be received for better quality."

6. "Would probably make some of the seasonal advantages disappear, and some would be hurt by this, but also would probably increase sales."

7. "Prolong market season and may encourage wholesaler to stock heavier. Would extend present export market and reduce need for foreign imports."

8. "Would allow shippers to withhold produce to avoid distress selling and market gluts. Could better regulate shipments and wait for better prices. Promote market stability and higher returns to growers and shippers."

9. "Biggest thing would be price stability across the board. Would be most helpful to housewife in storability and price stability."

10. "Encourage direct buying; buying brokers would be eliminated because of lack of short supply in terminal markets."

11. "No effect on production; matter of market supply and market demand, and not what fruit has been treated with."

12. "Would move more goods. This is the injection we need in the industry to combat frozen foods."

13. "People would buy more; price could be reduced at retail, and production in turn could be increased."

14. "Would eliminate the problem of fruit deterioration and kickback from buyer that fruit had gone bad after arrival."

15. "Would make marketing job easier and more efficient."

16. "Cultural production practices would remain about the same, but production volume would be increased."

Question 8.--In your opinion, how might radiation pasteurization affect sales and output of canned, frozen, and other processed forms of strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

Survey responses for the six commodities are (appendix A, table 14):

	Percent of respondents
Increase volume	2
Decrease volume	31
No change in volume	43
Do not know or no answer ..	24

The responses indicate the question was difficult to answer. Typical comments were:

1. "Will result in reduced purchases of fresh fruits and vegetables due to fear of radiation which in turn will improve sales of processed."

2. "I do not think it will affect overall, but possibly some at selected times of the year."

3. "No effect; no comparison; these are different products to the consumer."

4. "Probably reduce sales and output of processed forms, but not much as they are different products."

5. "No effect on sales and output. Consumers want convenience in processed items. People tend to eat fresh fruit during and shortly after harvest and processed fruit during the winter."

6. "There is a definite trend toward convenience foods. Irradiation may slow this trend. Canners will benefit from irradiated fruit the same as fresh fruit growers and handlers."

7. "It depends on the relative price relationships between processed and fresh."
8. "Would increase sales of processed because of complementary advertising effect when advertising irradiated produce. Sales of both will increase."
9. "Not much effect at the beginning because the consumer will be reluctant to accept. Later it will make large inroads into processed markets."
10. "People prefer fresh fruits and vegetables and will buy less processed if good fresh produce is available at competitive prices."
11. "Strawberry, cherry and other soft fruit consumption would increase in fresh irradiated form at the expense of canned, frozen and other processed forms."
12. "Will reduce frozen sales of strawberries; about the same for canned peaches and tomatoes because they are different products than fresh; sales and output of processed grapes, oranges and grapefruit will remain the same."
13. "Radiation processing would give a little more incentive for the consumer to consume a higher amount of fresh with very little effect on the other forms."

Question 9. --Where in the production and distribution chain (field, packinghouse, terminal market, or other) would radiation pasteurization processing best fit, and which type(s) of facility (large stationary centrally located facility for several handlers, a small stationary one at each handler's location, or a mobile facility) do you think is best for the processing location you selected for strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

A packinghouse or shipping-point location was preferred by 80 percent or more of the respondents for each commodity; less than 4 percent suggested the terminal market as the best location (appendix A, table 15). Sixteen percent of the respondents answering for strawberries thought a field processing location would be the best.

Respondents handling strawberries selected the type of facility they thought would be the best for strawberries as follows:

Proportion of respondents	Type of facility selected
One-sixth.....	small stationary one at each handler's location
Two-sixths.....	large, centrally located
Two-sixths.....	mobile
One-sixth.....	did not make a selection

Of those who selected a mobile facility, only one-third would use it in the field while the remainder of them thought it should be used at a packinghouse or shipping-point location.

Most respondents for peaches, grapes, oranges, and grapefruit thought a small stationary facility at a packinghouse or shipping-point location would be the best. But for tomatoes, nearly as many respondents thought a large stationary centrally located facility was needed as thought the small stationary facility was what they needed.

To answer question 9, respondents had to consider such factors as (1) the durability of the commodity, (2) changes required in present methods of physical handling during production and marketing if radiation processing were adopted, and (3) economic aspects of expected costs and benefits. Costs were emphasized by many respondents in their comments, some of which follow:

1. "Use mobile facilities in seasonal production areas and permanent facilities in year-around production areas."
2. "If facility was placed at the wholesale and retail level it would allow using for all fruits and vegetables."

3. "Do the process as rapidly as possible at the assembly point. The longer the process is delayed after harvest the greater and faster the breakdown."

4. "Better to process after fruit has been graded, sized and packed. An argument against a central facility is that fruit could not be hauled around because of the danger of damaging it."

5. "A packinghouse location is the most desirable from a handling viewpoint because it requires less handling. If cost can be brought down it would be handiest at each handler's location."

6. "Must have it on the conveyor where produce is going into packinghouse or into a rail car or else cost of handling would be increased."

7. "A small facility at the packinghouse would be the best because we have no time to rehandle and must use facility when it is needed."

8. "Cost would be prohibitive for the small volume of each handler's location."

9. "A large central facility would probably be the only feasible way from an economic viewpoint."

10. "Volume is needed in order to reduce unit costs, and this would require a large centrally located facility."

11. "A large central facility at a packinghouse location is required to reduce unit costs and give better quality and marketing control."

Question 10.--On the basis of your answer to question 9, what modifications in current produce handling methods do you think might be required in order to accommodate radiation processing of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

Of all survey respondents suggesting either a small stationary facility at each handler's location or a mobile facility in answers to the preceding question, 67 percent thought only minor or no changes would be required in present produce handling methods.[6] Eight percent thought a substantial change would be required while 25 percent failed to give a usable answer (appendix A, table 16).

Respondents suggesting a large stationary centrally located facility were about equally divided between either a minor change or no change, and a substantial change as being required in present handling methods.

Comments by respondents containing the main ideas in answers to question 10 are:

1. "No great problem; some modifications, investment and extra labor."

2. "If a facility is put in each individual plant, it would not change handling methods much; maybe one additional handling. If a central location, it would mean more changes in handling."

3. "Would be most economical to treat while fruit is still on conveyor. Then the only thing required would be the room or screened area and the conveyor to take produce in and out."

4. "Treat on conveyor before or after packing into lugs. Probably have to consolidate plants. The difficulty is to get individual shippers to combine operations."

5. "Would probably hasten the need for centralized packing operations; would cause some growers to go out of business or combine their operations."

6. "The market would handle more volume if spoilage were cut down; otherwise, handling methods would be about the same."

7. "The shipper would store and hold off the market to manipulate prices."

8. "More storage; could reduce the number of deliveries; otherwise, about the same."

9. "Could allow more time from purchase to delivery to promote more orderly marketing."

10. "The process would reduce rehandling operations."

---

[6] When the results for each of the two types of equipment were found to be closely comparable they were tabulated together as a group to simplify presentation. Also, all commodities are considered together because no substantial difference in survey results could be noted between commodities.

11. "May bring about changes in timing of harvest period. May be able to harvest produce when more mature."
12. "Could harvest vine ripe and have no deterioration."
13. "Could mean more prepackaging at shipping point."

Question 11. --List additional questions, suggestions and comments that you may have pertaining to radiation pasteurization?

The following comments and suggestions represent survey answers:

1. "Because research dealing with the process as it applies to fresh produce is so limited, it is difficult to make definite statements about the likely success or failure of it. The problems of moisture loss, recontamination, packaging, etc., need more research."
2. "Would increase grower costs; market would not absorb costs and would force many out of business."
3. "The end result must be proven beneficial. Then, the most economically sound firms adopt first and others are forced to follow if they want to meet competition."
4. "Assuming a facility costs $500,000, this would not stop growers. For lettuce, vacuum cooling was adopted quite rapidly. So I feel that investment costs would not deter development if the process helps. Costs are important, but it is uneconomical not to adopt a new process if it increases total returns."
5. "Process must not slow down production, must have a facility that will run at least 8,000 boxes of oranges in a 12-hour day."
6. "Cost of such a process is relatively meaningless because supply and demand sets the price at the market. We cannot tell how the process will go over until we try it."
7. "We are always looking for something better. Oranges and grapefruit can best be stored on the tree. They hold up pretty well now. Commodities like strawberries and others with high spoilage losses would seem to benefit most from radiation pasteurization."
8. "This process should be very helpful for tomatoes, watermelons and cantaloups because they cannot be frozen under present technology except for frozen watermelon cubes that must be eaten before thawed almost. The big benefits would be realized from spoilage loss reduction and quality maintenance."
9. "This process should be considerd for natural dried fruits, especially raisins, where there is a lot of spoilage loss."
10. "Make very sure the public is educated because if people get scared of the process it may ruin the industry. Get the American Medical Association in addition to the Food and Drug Administration to endorse the process because otherwise if one doctor states publicly that the process is harmful to health it could be disastrous to the produce industry."
11. "An educational program should be extended over a period of time rather than a one shot deal."
12. "Get moving as soon as possible on a pilot plant program with two or three highly perishable items including strawberries to see what the retailer's experience would be in the marketing of such commodities."
13. "Considerable produce buying is impulse buying. If the commodity looks good, the consumer will buy it. By maintaining quality, radiation pasteurization would be very helpful in securing impulse sales and at the same time consumption would be increased."
14. "The process should help growers considerably because it would eliminate or substantially reduce the amount of rejected produce upon government inspection at the terminal markets."
15. "If spoilage loss is cut down, then buyers will reorder more with confidence."
16. "Could ship more mature fruit, get better selection at packinghouse, better quality at retail, and higher prices to growers and shippers if radiation processing is adopted."

APPENDIX A

Data on Opinion Survey of Growers, Shippers, and Other Handlers of Six Commodities, 1962

TABLE 3.--Number of growers and shippers in sample, by States, 1962

State	Selected firms	State	Selected firms
California	78	Oregon	2
Florida	38	South Carolina	9
Georgia	6	Texas	11
Louisiana	7	Washington	6
New Jersey	11		
New York	3	Total	171

TABLE 4.--Percent of U.S. annual average 1954-58 production of selected commodities by major producing States, and total number of States producing each commodity

Major producing States	Straw-berries	Peaches	Tomatoes	Grapes	Oranges	Grapefruit
	Percent	Percent	Percent	Percent	Percent	Percent
California	40.5	53.7	52.5	91.4	24.0	4.6
Florida	1.4	--	6.7	--	73.8	83.7
Louisiana	3.7	--	--	--	--	--
New Jersey	1.7	[1] 3.0	5.3	0.1	--	--
New York	3.4	[1] 1.5	3.0	3.2	--	--
Oregon	[2] 15.0	--	--	--	--	--
South Carolina and Georgia	--	[1] 11.5	0.3	--	--	--
Texas	0.3	--	2.8	--	--	7.2
Washington	[2] 7.0	[1] 2.7	--	1.4	--	--
Total	7.30	72.4	70.6	96.1	97.8	95.5
	States	States	States	States	States	States
Number of States in commercial production	27	29	20	5	3	4

[1] Compiled from: U.S. Department of Agriculture. Fruits, Noncitrus, by States, 1954-59. Statis. Bul. 292, Crop Reporting Board, Aug. 1961.

[2] Nearly all of Oregon and Washington production is for processing.

Source: U.S. Department of Agriculture. Agricultural Statistics. Yearly.

TABLE 5.--Number of growers and shippers handling each commodity, by States, 1962

State	Straw-berries	Peaches	Grapes	Tomatoes	Oranges	Grapefruit
California.....	12	27	34	20	19	7
Florida.....	-	1	-	14	24	23
Georgia.....	-	6	-	-	-	-
Louisiana.....	7	-	-	-	-	-
New Jersey.....	8	9	-	3	-	-
New York.....	1	2	1	3	-	-
Oregon.....	2	-	-	-	-	-
South Carolina...	-	9	-	-	-	-
Texas.....	-	-	-	6	9	9
Washington.....	3	2	-	1	-	-
Total.....	33	56	35	47	52	39

TABLE 6.--Number of fresh produce wholesalers and chainstore produce managers interviewed from a sample of 135 firms in Boston, Chicago, and New York, 1962

Type of handler	Boston	Chicago	New York	Total
Wholesalers[1].....	30	32	49	111
Independent and cooperative chainstores.....	5	14	5	24
Total.....	35	46	54	135

[1] With few exceptions, all wholesale firms interviewed handled the six fresh produce commodities included in the study. Wholesalers include handlers, brokers, commission men, etc., located at the terminal markets.

TABLE 7.--Responses to question 1, "What might be the general reaction from the produce industry regarding radiation pasteurization of fresh fruits and vegetables?"

Respondent classification and location	Favorable	Not favorable	No conclusion	No comment	Total
Growers and shippers:					
California.....	51	13	12	2	78
Fla., Ga., and S.C....	42	0	10	1	53
N.J. and N.Y.....	10	3	1	0	14
Texas and La.....	15	0	3	0	18
Wash. and Ore.....	7	1	0	0	8
Subtotal.....	125	17	26	3	171
Wholesalers:					
Boston.....	18	4	8	0	30
Chicago.....	19	7	6	0	32
New York.....	29	7	11	2	49
Subtotal.....	66	18	25	2	111
Independent and cooperative chainstores:					
Boston.....	4	0	1	1	5
Chicago.....	8	5	0	1	14
New York.....	5	0	0	0	5
Subtotal.....	17	5	1	1	24
Total.....	208	40	52	6	306

TABLE 8.--Responses to question 2, "What might be the general reaction from consumers regarding radiation pasteurized fresh fruits and vegetables?"

Respondent classification and location	Favorable	Not favorable	No conclusion	No comment	Total
Growers and shippers:					
California.....	48	15	13	2	78
Fla., Ga., and S.C....	29	7	17	0	53
N.Y. and N.J.....	10	3	1	0	14
Texas and La.....	13	0	5	0	18
Wash. and Ore.....	8	0	0	0	8
Subtotal.....	108	25	36	2	171
Wholesalers:					
Boston.....	15	8	7	0	30
Chicago.....	14	12	6	0	32
New York.....	27	17	5	0	49
Subtotal.....	56	37	18	0	111
Independent and cooperative chainstores:					
Boston.....	5	0	0	0	5
Chicago.....	9	5	0	0	14
New York.....	5	0	0	0	5
Subtotal.....	19	5	0	0	24
Total.....	183	67	54	2	306

TABLE 9.--Number of respondents giving specified replies to question 3, "What advantages might come from radiation pasteurization of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?

Advantages given	Straw-berries	Peaches	Tomatoes	Grapes	Oranges	Grapefruit
Reduce spoilage loss and increase shelf life.....	58	88	71	65	76	65
Maintain quality and better appearance.....	58	98	78	63	75	65
Expand established markets.	21	33	25	28	26	24
Develop new markets.....	9	17	10	10	11	10
Will tend to stabilize markets.....	25	36	25	20	20	17
Facilitates distribution...	16	20	15	21	17	16
Lengthen market season.....	21	35	21	15	23	18
Reduce costs of handling and transportation.....	11	10	16	11	6	6
Can ship longer distances..	10	10	6	7	7	7
Will result in improved merchandising methods....	10	16	13	10	13	12
Miscellaneous.....	4	8	6	6	13	12
No advantages to the process.....	7	9	16	7	10	10
No answer or cannot determine.....	11	14	15	9	9	8
Respondents handling commodity.....	112	164	141	112	131	116

TABLE 10.--Number of respondents giving specified replies to question 4, "What disadvantages might come from radiation pasteurization of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?"

Disadvantages given	Straw-berries	Peaches	Tomatoes	Grapes	Oranges	Grapefruit
Consumer resistance due to fear of the process.....	58	77	72	55	63	59
Will require an extensive educational program.....	32	44	36	39	47	39
Increased processing costs.	35	57	41	35	38	29
Increase surplus or market supplies.....	6	6	8	1	2	2
Miscellaneous answers.....	13	16	19	11	15	14
No disadvantages.....	13	23	17	15	24	23
No answer or cannot determine.....	7	11	11	6	6	5
Respondents handling commodity.....	112	164	141	112	131	116

TABLE 11.--Summary of responses to question 5, "From a marketing and consumer viewpoint, what would be the most desired number of days extension of the refrigerated storage life by radiation pasteurization of fresh strawberries, peaches, tomatoes, grapes, oranges and grapefruit?"

Item	Straw-berries	Peaches	Tomatoes	Grapes	Oranges	Grape-fruit
Respondents handling.....	112	164	141	112	131	116
Total responses.....	66	101	90	62	92	78
Positive responses.....	52	75	61	46	68	54
Zero responses.....	14	26	29	16	24	24
Range of positive responses in days.....	1-270	1-270	1-270	3-195	2-75	4-75
Ave. of positive responses in days.....	10.4	19.0	24.2	30.5	14.5	14.2
Ave. of all responses in days..	8.2	14.1	16.4	22.6	10.7	9.8

TABLE 12.--Number of respondents giving specified replies to question 6, "On the basis of your judgment--what is your best estimate of the cost you could afford to pay for radiation pasteurization of strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?"

Estimated cost that respondents could pay per pound	Straw-berries	Peaches	Tomatoes	Grapes	Oranges	Grape-fruit	Total replies
Zero.....	9	8	17	8	13	13	68
Less than 0.5 cent.....	8	34	20	24	47	36	169
0.5 to 0.9 cent.....	5	21	6	9	4	3	48
1 to 1.4 cents.....	9	10	9	5	1	1	35
1.5 to 1.9 cents.....	11	2	5	0	1	1	20
2 to 2.9 cents.....	8	2	1	3	1	1	16
3 to 3.9 cents.....	1	0	0	0	0	0	1
4 to 6 cents.....	5	0	1	0	0	0	6
Saving in spoilage is maximum amount that could be paid.....	3	3	4	3	4	4	21
10 to 20 percent more than cost of present methods of preservation.....	0	1	1	1	0	0	3
No answer or cannot determine.....	53	83	77	59	60	57	389
Total.....	112	164	141	112	131	116	776

TABLE 13.--Number and percentage of respondents giving specified replies to question 7, "If radiation pasteurization is proved to be commercially feasible and is adopted by the produce industry, how might it affect the production and marketing of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?"

Expected effect on production and marketing	Strawberries		Peaches		Tomatoes		Grapes		Oranges		Grapefruit		Total replies	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Increase.....	59	53	75	46	58	41	52	46	64	49	58	50	366	47
Decrease.....	7	6	12	7	9	7	9	8	11	8	11	10	59	8
Remain the same....	13	12	25	15	23	16	20	18	17	13	14	12	112	14
No answer or cannot determine.....	33	29	52	32	51	36	31	28	39	30	33	28	239	31
Total.....	112	100	164	100	141	100	112	100	131	100	116	100	776	100

TABLE 14.--Number and percentage of respondents giving specified replies to question 8, "In your opinion, how might radiation pasteurization affect sales and output of canned, frozen and other processed forms of strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?"

Expected effect on production and marketing	Strawberries		Peaches		Tomatoes		Grapes		Oranges		Grapefruit		Total replies	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Increase.....	2	2	4	2	3	2	3	3	3	2	3	3	18	2
Decrease.....	41	37	52	32	36	25	36	32	38	29	33	28	236	31
Remain the same.....	42	37	71	43	70	50	48	43	56	43	48	41	335	43
No answer or cannot determine.....	27	24	37	23	32	23	25	22	34	26	32	28	187	24
Total.....	112	100	164	100	141	100	112	100	131	100	116	100	776	100

TABLE 15.--Number of respondents giving specified replies to question 9, "Where in the production and distribution chain would radiation pasteurization processing best fit, and which type(s) of facility do you think is best for the processing location you selected for strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?"

Proposed location and type of radiation processing facility	Straw-berries	Peaches	Tomatoes	Grapes	Oranges	Grape-fruit
Field:						
Large centrally located facility	1	0	0	0	0	0
Stationary at each handler's location	1	0	1	0	0	0
Mobile facility	13	2	2	2	0	0
No facility designated	3	4	2	1	2	1
Packinghouse or shipping point:						
Large centrally located facility	34	38	38	23	22	18
Stationary at each handler's location	17	69	41	47	71	62
Mobile facility	23	28	32	21	16	15
Two facilities designated[1]	8	8	8	6	5	5
No facility designated	8	12	11	10	12	12
Terminal market:						
Large centrally located facility	3	1	1	1	2	2
Stationary at each handler's location	0	1	3	1	0	0
Mobile facility	0	0	0	0	0	0
No facility designated	0	0	1	0	1	1
No location or facility designated	1	1	1	0	0	0
Total	112	164	141	112	131	116

[1] Mostly large and small stationary facilities were designated.

TABLE 16.--Number of respondents giving specified replies to question 10, "On the basis of your answer to question 9, what modifications in current produce handling methods do you think might be required in order to accommodate radiation processing of fresh strawberries, peaches, tomatoes, grapes, oranges, and grapefruit?"

Estimated change in handling methods, by type of facility selected by respondents	Strawberries	Peaches	Tomatoes	Grapes	Oranges	Grapefruit	Total replies
Large stationary centrally located facility:							
Substantial.....	19	16	17	10	8	7	77
Minor or no change....	18	17	14	11	14	12	86
No answer or cannot determine.....	5	9	9	5	4	3	35
Total.....	42	42	40	26	26	22	198
Small stationary facility at each handler's location or a mobile facility:							
Substantial.....	7	10	8	3	5	5	38
Minor or no change....	33	59	53	49	60	53	307
No answer or cannot determine.....	15	30	18	14	20	18	115
Total.....	55	99	79	66	85	76	460

APPENDIX B

Letter and Enclosure Sent to Each Respondent

UNITED STATES DEPARTMENT OF AGRICULTURE
Economic Research Service
Washington 25, D. C.

(Date)

(Address)

Gentlemen:

The Atomic Energy Commission is engaged in comprehensive research on the radiation pasteurization of certain fruits and vegetables as part of the "Atoms for Peace" program. Relatively low doses of radiation are used to inhibit growth of microbes responsible for spoilage and thus has a potential for extending the marketing life of those commodities.

The U.S. Department of Agriculture has been requested by the Atomic Energy Commission to interview growers, shippers and other members of the produce trade to obtain their opinions, judgments, and estimates regarding the feasibility and acceptability of marketing radiation pasteurized fresh strawberries, peaches, grapes, citrus and tomatoes. The enclosed sheet gives a very brief general description of the radiation pasteurization process and preliminary cost estimates developed by Stanford Research Institute.

Personnel of the Horticultural Crops Section will be in your area during the next few weeks and may visit your firm during this survey. If you are contacted, your cooperation will be appreciated; and we wish to emphasize that all information about your firm or business will be treated strictly confidential and will be released only as average data representing a number of similar firms.

Sincerely yours,

Loyd C. Martin
Head
Horticultural Crops Section

Enclosure

Enclosure

IRRADIATION PRESERVATION AND PRELIMINARY COST ESTIMATES

"Research in the use of atomic energy for food preservation began on a large scale in 1953. Because of the many complex problems associated with radiation sterilization, researchers have found that the use of low doses for pasteurization is the most practical method. There are several factors responsible for effective radiation preservation; first, radiation dose; second, selection of variety and maturity of product; third, preirradiation treatment; and fourth, packaging. The radiation dose required depends on the number and kind of microbial organisms present on the product before irradiation. Without loss of quality, most fruits and vegetables can be irradiated at a medium level... to extend the shelf life from two to six weeks at refrigeration temperatures."[1]

Atomic irradiation retards and destroys micro-organisms in food which are responsible for spoilage; thereby allowing an extension of the storage life. Radiation dosages of a number of times the intensity needed for pasteurization are required before any danger to human health is possible from radiation in food. Wholesomeness tests have shown that radiation pasteurized fruits and vegetables are acceptable for human consumption in a similar manner as their fresh forms when quality, taste, color, etc., are considered. In addition, research has shown that this new process can be used effectively to control ripening of fresh produce.

"The cost of radiation sources differs with such variables as the type of source, the size of plant, and the load factor at the plant. Based upon existing knowledge, an estimate has been made that in a 10-ton-per-hour facility with annual volume of 40,000 tons per year, a gamma source could process fruit at a cost of approximately five mills per pound. This might add 25 percent or more to the costs of a typical orange packing operation, and for other commodities the increase might be even greater. Whether this cost is at a level at which packers will be encouraged to use radiation pasteurization depends on the potential economic advantages the user may realize from the process."[2]

Based on cobalt 60 at a cost of 50 cents per curie, the initial cost of penetrating source material for a facility of the size indicated above would be about $720,000; and in addition, the plant investment would be about $380,000. Today, the price of cobalt 60 is about $1.00 per curie.[3] It should be noted that the research and development time necessary to produce a commercial size facility has been estimated to be about four years. The table below contains preliminary cost estimates.

A surface treatment facility large enough to handle 40,000 tons per year with a 10-ton-per-hour capacity would be expected to cost about 1/10 as much as for a penetrating source. The cost per unit for processing then would be about 1/5 as much as for a penetrating source such as cobalt 60. Accelerated electrons and strontium 90 are examples of surface treatment sources. It should be emphasized that surface source technology is not thoroughly developed yet, and to develop it for commercial application implies a long-term research and development effort.

[1] Pierson, N.W., Wilcox, E.B. and Salunkhe, D.K. Radiation Preservation of Fruits. Utah Farm and Home Science, Vol. 23, No. 1, Agricultural Experiment Station, Utah State University, Logan, March 1962, Quarterly.

[2] Stanford Research Institute. Radiation Preservation of Selected Fruits and Vegetables. SRIA-30, Jan. 1961, p. 17.

[3] SRIA-30, p. 54. A curie is a unit of mass of radium emanation, being the amount in equilibrium with one gram of radium.

Lowest cost of irradiating food at selected production volumes, by size of facility and type of source

Source capacity by type	Lowest cost (mills per lb.) at annual production volume of--				
	1,000 tons	5,000 tons	10,000 tons	20,000 tons	40,000 tons
Tons per hour					
Penetrating:	Mills	Mills	Mills	Mills	Mills
5.....	100	22	12	7	4
10.....	-	34	12	10	5
Surface:					
1.....	10	7	-	-	-
5.....	7	3	2	2	2
10.....	--	2	1	1	1
20.....	--	2	1	1	1

Source: Stanford Research Institute. Radiation Preservation of Selected Fruits and Vegetables. SRIA-30, Jan. 1961, p. 60. Operating costs include direct labor plus 100 percent overhead, isotope source replenishment or power source replacement, utilities, and miscellaneous repair parts.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250