

TRENDS IN BLUEBERRY UTILIZATION AND CONSUMER
PREFERENCE TEST OF PRODUCTS FROM TWO NEW
PROCESSING TECHNOLOGIES FOR BLUEBERRIES:
DEHYDROFREEZING AND EXPLOSIVE-PUFFING

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by

Dennis Stevenson Isidro

AN ABSTRACT

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ABSTRACT

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by DENNIS STEVENSON ISIDRO

The rising trend in food processing, particularly in fruits and vegetables, and the increasing per capita consumption of processed foods and the possible economic changes resulting from the adoption of newly developed food processing technologies aroused the investigation of blueberry production, consumption, and utilization.

Because of the increasing freight rates, expensive storage fees, relatively high packaging outlay, and institution and consumer demand for convenience food products, studies of some potential new processing methods were undertaken to determine the feasibility of their use for blueberries to reduce cost of processing, storage, packaging, and distribution, and therefore increase the sales of blueberry products.

The objectives of this study, therefore, were (a) to review the trends in blueberry production, consumption, processing, and utilization, (b) to review the development of new fruit and vegetable processing technologies and their economic significance, and, (c) to make a progress report on the feasibility of using products from two new processing

methods for blueberries, the dehydrofreezing and the explosive-puffing, by determining the consumer preference for these two new product forms compared to standard forms.

The production of blueberries, in Michigan and nationally, has increased significantly over the past three decades. Projections indicated a continued increase in blueberry production in Michigan over the next several years. Total and per capita consumption of both fresh and processed blueberries is increasing and consumption is concentrated relatively near to areas of production. Over half of the total blueberry crop is processed and the principal uses of the processed products are in pies and in blueberry muffins. Typically, blueberries are more expensive than most fruits used in pie form and limited data would indicate a relatively high elasticity of demand for fruit pies. Thus, because of the large quantities of blueberries processed for subsequent use in pies and in muffins, and because of the relatively higher prices of blueberries compared to other major fruits, and because of the high elasticity of demand for the final products, if cost reducing processing technologies could be developed for blueberries, increases in sales of blueberry products should result.

Two new processing methods, dehydrofreezing and explosive-puffing have been reviewed with other food processing methods also applicable to fruits and vegetables to show where the new technologies fit in the spectrum of all processing

technologies and also to show the advantages and disadvantages of the new technologies as compared to other currently possible technologies.

Products from two new processing technologies were considered in this study, the dehydrofreezing process and the explosive-puffing process. The freeze-drying process was not considered mainly because at the present stage of development a high cost of processing is involved. Each of these two new processing techniques (dehydrofreezing and the explosive-puffing process) yields products which might be adaptable for use in many types of blueberry products, i.e., for use in pies, muffins, pancakes, jellies and jams.

Dehydrofrozen blueberries were experimentally produced by the Food Science Department, Michigan State University and quick-cooking blueberries were produced experimentally by the U.S. Department of Agriculture, Eastern Regional Research and Development Division, Philadelphia, Pennsylvania expressly for use in consumer panel tests.

Consumer preference tests of products from the new technologies were conducted through the Michigan State University consumer preference panel in Detroit. The tests reported here are to be considered as preliminary tests only and were conducted under laboratory conditions. Only a limited number of test runs were conducted as it was the first season in which either of the new processing technologies was tried on blueberries.

Normally frozen blueberries were compared to dehydro-frozen control (no pre-treatment), dehydrofrozen pricked, and dehydrofrozen nicked blueberries in pie forms. The consumer preference tests indicated a highly significant preference for normally frozen blueberry pies over both the dehydro-frozen control and the pre-treated dehydrofrozen blueberry pies, but no significant differences were found between the (control) regular dehydrofrozen and pre-treated dehydrofrozen blueberries in pie form.

In a triangle test comparing pies from the dehydro-frozen control to dehydrofrozen pricked blueberries, the discernment of differences was significant but the preferences between the two types of pie were not significant.

The dehydrofrozen blueberry pies were not as acceptable as normally frozen blueberry pies. This could have been due to technology or to the recipe of the pies. However, the success of dehydrofrozen apples and the savings in packaging, storage, and distribution costs suggest that work on the dehydrofreezing process on blueberry be continued.

In two triangle tests, comparing muffins made from quick-cooking and ordinary canned blueberries, there was a significant discernment of differences, but a non-significant preference. Thus under the conditions of the test, the quick-cooking blueberries prepared by the explosive-puffing process were as acceptable as the normally canned blueberries in muffin form.

When the two tests of muffins were combined into one group panel of 303 consumers, the difference in preference was barely significant at the 5 percent level.

A consumer preference panel screening test was conducted of blueberry pies made from frozen, canned and quick-cooking blueberries. In this test the pies made from quick-cooking blueberries were ranked the lowest by a significant number of consumers. Due to the limited quantity of quick-cooking blueberries only a few experimental recipes were tested before the consumer panel test was conducted. It is suggested that better recipes for quick-cooking blueberries for use as pie fillings might be developed which might change the results of this initial screening test.

Thus, initial tests of quick-cooking blueberries from the explosive-puffing process yielded very promising results in muffin form. The dehydrofrozen blueberries and the quick-cooking blueberries yielded fairly poor results in pie form. However, it is strongly suggested that these initial screening tests be repeated after more technical work is done on the processes themselves, on reconstitution of these processed blueberries, and baking procedures because of the inherent savings in these new processing techniques.

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Chapter I

INTRODUCTION

Increasing freight rates, expensive storage cost, relatively high packaging outlay, and institution and consumer demand for convenience food products are playing major roles in changing the technology of fruit and vegetable preservation to dehydration. Specialization of production which necessitates long distance shipping to markets has also played a major role in increased dehydration. Although this specific study is on blueberries the general trends in costs apply to blueberries as well as other fruits and vegetables. There have been marked improvements in the technology of food dehydration. Among the recent developments are drum drying, spray drying, vacuum drying, foam mat drying, dehydrofreezing, and explosive puffing.

From 1951 to 1961 railroad freight rates increased by 8 percent while during this same period, consumer prices for all items increased by 11.7 percent. During this period consumer prices increased at a faster rate than railroad freight rates. In real terms, however, railroad freight rates have decreased slightly over a period of 11 years. (See Tables 1.1 and 1.2)

Truckload rates for food have also been increasing. In Michigan from 1950 to 1961, shipping rate for 100 pounds of food for a distance of 100 miles has increased by 96.23

percent, for 200 miles 90 percent, for 300 miles 84 percent and for 400 miles 80.32 percent. (See Table 1.3)

In 1961 the railroad cars carried approximately 14 percent of all frozen foods shipped in the United States while trucks and trailers handled about 86 percent.¹

As a result of the expensive maintenance of refrigerated shelf space at the retail level, the availability of shelf space for frozen and fresh fruits is very limited compared with storage and display of some other processed products. Thus, substantial savings and increased space for display of products may be realized upon acceptance of dehydrated products.

In general, packaging costs for dehydrated products are generally much less than for frozen or canned. For example, a comparative container cost study indicated that container cost for dehydrofrozen green peas was lower than that of frozen and canned peas. Container cost of dehydrofrozen peas was 50 percent lower than that of frozen peas and about 73 percent lower than that of canned peas.²

¹"Railroad Offers Incentive Rates to Induce Frozen Food Freight," Quick Frozen Foods, August 1963, pp. 311-312.

²M. J. Conley, "The Outlook for Freezing and Dehydrofreezing in Food Preservation," paper presented at the meeting of American Society Refrigeration Engineers, Chicago, November 14, 1957.

Table 1.1. Index Number of Railroad Freight Rates for Fruits and Vegetables (1957-1959 = 100).

Year	Index No.	Year	Index Number
1951	89	1956	93
1952	94	1957	102
1953	93	1958	100
1954	93	1959	97
1955	93	1960	96
		1961	97

Source: United States Department of Agriculture, Agricultural Statistics, 1962, p. 721.

Table 1.2. Consumer Price Index (1957-1959 = 100)

Year	All Items	Food	Year	All Items	Food
1951	90.5	95.4	1959	100.7	101.9
1952	92.5	97.1	1959	101.5	100.3
1953	91.2	95.6	1960	103.1	101.4
1954	91.6	95.4	1961	104.2	102.6
1955	91.3	94.0	1962	105.4	103.6
1956	94.7	94.7	1963	106.7	103.1
1957	98.0	97.8			

Source: Economic Indicator, U.S. Government Printing Office, Washington, 1963, p. 26.

Table 1.3. Intrastate Truckload Class Rates of Food^{2/} at Various Distances, 20,000 Pounds Minimum Weight, Michigan, 1950 and 1963.

Distance in Miles				
	100	200	300	400
Rates in cents per 100 lbs.				
1950 ^{1/}	27	40	50	61
1963 ^{2/}	53	76	92	110
Percent Increase	96.3	90.0	84.0	80.3

^{1/}The term Food includes, frozen, aired, cooked, prepared.

^{2/}Sources: Michigan Public Service Commission, Opinions and Orders, Docket D-34 76, Supplemental Order No. 6, April, 1960, p. 40.

^{3/}Sources: National Motor Freight Traffic Association, National Motor Freight Classification, September 6, 1963, p. 352.

In the last fifty years eating away from home has exhibited a rising trend. This is a clear indication that more and more meals are eaten in institutional feeding establishments such as restaurants, cafeterias, hotels, in-plant feeding services, schools, prisons and other private or public establishments serving meals on a regular basis. Because of the rising labor cost and high labor requirements in preparing meals from unprocessed, unprepared, raw materials and because of the need to serve the customer within a very short period of time, these feeding establishments

have accepted many prepared products or processed products to serve the ever increasing meals eaten away from home.

Meals eaten away from home have risen from less than 5 percent in 1903 to 20 or more percent in 1960. It has been estimated that by 1970, 30 to 50 percent of the meals will be eaten away from home.³

United States expenditure on foods and beverages amounted to \$1.1 billion dollars in 1961 and 20.8 million dollars or 25.6 percent was spent on meals and beverages purchased in public eating places. This is a clear indication that over 25 percent of the money spent on food and beverages was used to purchase meals eaten away from home.⁴

The increase in the demand for processed products has been partially reflected in the index of processing. From 1909 to 1958 the index of processing of all farm products indicated a 240 percent increase, and processing of fruits and vegetables, 280 percent, one of the largest increases in food processing from 1909 to 1958.⁵

³W. Smith Greig, "Market Development for Cherries" Talk given to cherry growers at Traverse City, Hart, and Benton Harbor, Michigan, on October 3, 4, and 5, 1962, respectively.

⁴L. Marine, "Testing Institutional Acceptance of New Food Products by Means of an Institutional Sales Test" (unpublished manuscript, Department of Agricultural Economics, Michigan State University, 1962), p. 11.

⁵Ibid.

Another possible reason for such shift to processed food items is the high perishability rate for fresh foods delivered from wholesale market to the institutional feeding establishment.

Thus, the rising transportation rates, expensive storage rates, relatively high packaging outlay, and institution and consumer demand for convenience food products, resulted in increased efforts of food technologists to develop new cost reducing food processing technologies which yields a high quality of processed products.

Even if the transportation rates, storage rates, and packaging cost had remained stable in the past, the enormous reduction in weight and volume of some dried foods and the tremendous savings arising from storage, all these would tend to increase efforts to search for cost reducing technologies.

B. Trends in Food Processing and Consumption

In addition to the factors that influenced the initiation of studies on dehydration as a means of preserving food, the rising trend in food processing, particularly fruits and vegetables, and per capita consumption of processed foods aroused the investigation of blueberry utilization and feasibility of using products from some new processing technologies on blueberries.

Processing of farm food products has greatly expanded in the United States over the last 55 years. Factory production of processed domestic farm food products increased about

240 percent from 1909 to 1958.⁶ Factory production index of farm food also increased about 145 percent between 1919 and 1957.⁷ Most commodity groups have increased in factory processing. Poultry, fruits and vegetables categories have shown the largest increases during the last half century.

Between 1910 and 1958, factory processing of fruits and vegetables rose 674 percent while farm marketings increased by only 156 percent.⁸

About one-half of the civilian purchases of fruits and vegetables was canned or frozen in packing plants in 1953, while only one-fourth in 1919.⁹

Factory production of processed fruits and vegetables accounts for one-eighth of total factory production of all processed farm foods.

From 1909 to 1953, a 50-year period factory production of processed fruits and vegetables increased at the rate of 4.3 percent per year. However, annual rate of growth after World War II was 4.2 percent compared with the

⁶W.H. Waldorf, Output of Factories Processing Farm Food Products in the United States, 1909-1953, U.S. Department of Agriculture Technical Bulletin No. 1223, (Washington: U.S. Government Printing Office, 1960), p. 4.

⁷Ibid., p. 1.

⁸Ibid., p. 23.

⁹Ibid.

pre-war rate of 1.6, 1909 to 1939.¹⁰

Two-fifths of the increase in factory production of processed fruits and vegetables is associated with increased farm marketing of fruits and vegetables and three-fifths is associated with increased proportion of farm marketings of fruits and vegetables processed in factories compared to fresh consumption. There has been a shift from home canning and preserving to factory canning and freezing.¹¹ There has been a pronounced trend towards factory processing of fruits and vegetables. This shift, from fresh to factory processing has been the result of (a) increased per capita consumption of home and factory canned and frozen fruits and vegetables, (b) factory displacement of home canning and preserving, (c) increased urbanization of the American population. City families consume more processed fruits and vegetables and can and freeze smaller quantity at home than do either rural non-farm or farm families.¹²

C. Fruit consumption trends.

U.S. per capita consumption of all fruits has been rising steadily. It was 153.8 pounds in 1910, 170.8 pounds

¹⁰ *Ibid.*, p. 22.

¹¹ *Ibid.*, p. 22.

¹² *Ibid.*, p. 24.

in 1930, 187.9 pounds in 1950 and 191 pounds in 1961.¹³

Several changes have been taking place in the fruit consumption (See Table 1.4). (a) From 1920 to 1961, U.S. per capita consumption of fresh fruit declined from 145.4 pounds to 92.2 pounds, a 36 percent decrease.¹⁴

(b) Per capita consumption of canned fruits and juices increased 223.6 percent from 1920 to 1945, but per capita consumption averaged about 52.3 pounds with very slight variations in consumption from 1950 to 1961.¹⁵

(c) Per capita consumption of frozen fruits increased about 162 percent from 1950 to 1961.¹⁶

(d) Per capita consumption of dried fruits decreased about 32 percent between 1910 and 1961.¹⁷

It is interesting to note that U.S. per capita consumption of all fruits has shown an increasing trend while that of fresh and dried fruits has exhibited a declining trend. Per capita consumption of canned and frozen fruits has exhibited a rising trend.

¹³ Consumption of Food in the United States 1909 to 1952, (Supplement for 1961) Comm. Econ. Agr., Agricultural Handbook No. 62, September 1962, p. 22.

¹⁴ Ibid.

¹⁵ Ibid.

¹⁶ Ibid.

¹⁷ Ibid.

Table 1.4. Per Capita Consumption: All Fruits, Fresh, Canned, Frozen, and Dried Fruits,
1910 to 1961

Year	All Fruits	Fresh	Canned and Canned Juice	Frozen	Dried
1910	151.8	137.9	4.6	B/	16.3
1915	163.5	157.3	6.3	B/	17.9
1920	184.8	145.4	12.6	B/	26.8
1925	172.7	135.8	12.0	.2	23.7
1930	170.8	133.6	16.6	.6	20.0
1935	177.5	136.5	20.9	.6	19.5
1940	203.7	142.1	37.5	1.2	22.9
1945	208.2	142.0	41.4	2.7	22.1
1950	187.9	106.8	52.8	13.7	14.6
1955	200.6	100.6	51.9	34.8	13.3
1960	200.2	97.4	53.4	38.2	11.2
1961	191.0	92.2	51.8	35.9	11.1

B/ Farm weight equivalent.

b/ Data not available.

c/ Civilian consumption only beginning 1941.

Source: Consumption of Food in the United States 1909 to 1952,
(Supplement for 1961) U.S.D.A., and, Agricultural Handbook,
No. 62, September 1962, p. 72.

Table 1.3. Per Capita Consumption of Fruits and Vegetables in Fresh and Processed Forms, 1935 and 1960.

	Fresh		Processed		Total	
	1935	1960	1935	1960	1935	1960
Pounds of Per Capita Consumption						
Citrus [✓]	44.6	33.7	3.6	52.6	48.2	86.3
Fruits (Other than Citrus) [✓]	91.9	64.7	37.4	50.1	129.3	114.8
Vegetables [✓]	111.2	101.9	47.0	99.3	158.2	201.5
Totals	247.7	200.3	88.0	202.3	335.7	402.6

[✓] U.S. Department of Agriculture, The Fruit Situation, January, 1961, pp. 24-29.

[✓] Consumption Trends and Patterns for Vegetables, Potatoes, Sweet Potatoes, Alfalfa and Beans, U.S. Department of Agriculture, Agricultural Handbook No. 215 (Washington: U.S. Government Printing Office, 1961), p. 11.

Table 1.3 shows that annual per capita consumption of processed fruits and vegetables increased from 88 pounds in 1935 to 202.3 pounds in 1960. The 130 percent increase in per capita consumption of processed fruits and vegetables compares to an increase of only 20 percent in total per capita consumption of fruits and vegetables.

B. Forecast of Processed Food Consumption

Consumption of commercially processed foods is affected by factors affecting supply and demand. The factors

affecting supply are technological changes, cost relationships, and changes in marketing institutions, while factors affecting demand include income, urbanization, home-food production, and employment and education of homemakers.¹³

Technological changes and changes in marketing institutions have had considerable influences on the consumption of processed foods. These changes include improvement in freezing and dehydration of fruits and vegetables, which have made possible the marketing of many convenient, high-quality foods such as instant coffee, instant tea, frozen fruit juice concentrate, cake mixes, frozen poultry and frozen vegetables. These have been available as a result of technological advances. The shift of consumption from unprocessed to processed foods has been the result of processing that yielded high quality and convenient food products.

In the long run, prices of processed products decrease due to savings in packaging, transportation, and handling charges, and concentration of production in low-cost producing areas. Retail prices of processed fruits and vegetables, for example, have increased at a slower rate than their

¹³ H. C. Burk, Consumption of Processed Farm Foods in the United States, U. S. Department of Agricultural Marketing Research Report, No. 409, (Washington: U. S. Gov't Printing Office, 1960), p. 20.

unprocessed counterpart.¹⁹ From the supply side, we can also consider the factors that are likely to affect the change in processing foods, but we cannot measure the net cost of improvements and their effects. These factors affecting supply of processed foods are as follows:

- (a) further technological changes are likely to continue,
- (b) cost of transportation and handling foods in all forms are likely to continue to rise with changes in wage rates,
- (c) problems in handling supplies in congested metropolitan areas are expected to continue,
- (d) higher cost of materials in handling is likely to continue unless more efficient methods of handling are developed,
- (e) improvement in handling of fresh and frozen products is necessary to maintain quality in order to regain and hold consumer acceptability.²⁰

On the demand side, factors that indicate increased processing of farm foods are:

- (a) Because of the rising labor cost in restaurants

¹⁹ R.G. Harris and F.P. Dworkin, "Convenience Foods and their Cost to Consumers," The Marketing and Transportation Situation, July 1958, p. 28.

²⁰ Burk, op. cit., p. 33.

and other eating establishments, the demand for factory processed foods by these establishments have increased substantially.

(b) Meals eaten away from home have increased in the last half century. In 1960, over 20 percent of the meals were eaten away from home as compared to 5 percent in 1901.²¹ The increase suggests that more meals will be served by restaurants and other eating establishments.

(c) The increase in the household consumption of processed foods will depend on increased real income, urbanization shifts, and changes in consumption patterns. Burk projected that if real income per capita will rise by 50 percent, this increase will generate a 5 to 7 percent increase in the per capita purchase of processed and unprocessed foods.

Income as a factor affecting demand for processed farm foods has increased considerably the consumption of processed foods. Burk indicated that increased income increased expenditure on canned foods 5 to 10 percent, on frozen foods 15 to 25 percent, and on other forms of processing about 10 percent.²²

²¹W.S. Greig, Market Development for Cherries, Talk given to Cherry Growers Association at Traverse City, Hart and Benton Harbor, Michigan, October 3, 4, and 5, 1962, respectively.

²²Burk, Loc. cit., p. 30.

French also indicated that consumption of commercially prepared pies per family and per person increased substantially as family income moved up from a low to a moderate level.²³

Burk indicated that urbanization shift in the next 15 years is not likely to have much effect on changes in the food picture. However, in the last 20 years, purchases of processed foods were affected by urbanization shifts much more than unprocessed foods. This was contrary to the findings from Statistic Cross-section data.²⁴

The shifts of population to urban areas increased consumption of processed and unprocessed farm foods 2 to 4 percent per person, according to Burk.²⁵

Households with employed homemakers use more bakery products per person than households with homemakers who did not have outside employment. More frozen fruits and vegetables were used by homemakers with more educational attainment.²⁶

²³A.C. French, "Some Economic Aspects of Pie Consumption," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, Volume 41, No. 3, February, 1959, p. 492.

²⁴Burk, loc. cit., p. 34.

²⁵Burk, loc. cit., p. 30.

²⁶Ibid., p. 32.

E. Possible Effects of Changes in Technology

The vast developments and introduction of new technology, particularly dehydration and freezing, have brought about a shift in the location of vegetable production.

According to Greig, potato production shifted from Maine, North Central Region, California, Florida and Texas to Idaho. This shift in the location of potato production has been due primarily to the dehydration and freezing of potato products in Idaho.

A shift in onion production is currently taking place from New York and Michigan to California. There seems to be a direct correlation between the increase in acreage in California and increase in onion dehydration. Onion acreage in Michigan and New York has remained fairly constant while that of California has increased significantly.²⁷

In Minnesota, Washington, Oregon, Illinois and Idaho, production of green peas for processing has been rapidly rising. In effect, production of green peas for processing has been increasing and that of fresh green peas has been declining.

There has been a shift of green pea production from Texas, Pennsylvania, Maryland and New York to Minnesota.

²⁷W. Smith Greig, "Market Development for Cherries," a speech delivered to the Cherry Growers Association at Traverse City, Hart, Benton Harbor, Michigan, October 3, 4, and 5, 1962, respectively.

Washington, Oregon, Illinois and Idaho. The increase in green pea production in these areas could be attributed to the increased production of peas for processing.

Various dehydration and freezing techniques have preserved foods in such a way that in spite of the seasonability in farm production, different farm products have been available all year round.

A tremendous reduction in storage, handling, and transportation cost is realized when dehydration of food products is employed because a high percentage of the moisture is extracted from the fresh food product and in some dehydration process, volume is reduced by from 50 to 90 percent of its original volume. Because of such reduction in volume, the packaging cost is also reduced by packing a greater weight of food products in a container of a given size and by using low cost containers since no liquid drains from the processed food. Transportation cost can also be reduced by about 50 percent to as much as 75% because of the reduction in weight and because refrigeration is no longer needed.

Shifts in the market structure are likely to occur as new dehydrated food products are developed. It is possible that the use of a large volume of dehydrated products could increase substantially the economies of scale of production of the processed products. It would enable food manufacturers to prepare a specific product such as blueberry pie from

dehydrated blueberries, for 24 hours continuously for national distribution. National distribution of both dried blueberry pie fillings and dried pies become feasible and economical as these dried products could be stored over a long period of time and as more quantities of dried blueberries may be shipped at lower freight cost than fresh or can blueberries.

National distribution under brand names becomes feasible. National distribution may mean distribution of products by only a few food manufacturers and large amounts of advertising and promotion of their brand names is likely to take place.

Chapter II

OBJECTIVES

In addition to the above factors that stimulated vast improvements in the technology of food processing, the increasing trend in blueberry production, processing, and utilization, the expanding total consumption and per capita consumption of blueberries, the concentration of blueberry production in Michigan and along the East Coast, the relatively elastic demand for commercially prepared fruit pies, the increasing demand for pie fillings, jellies, and commercially prepared pies, and the fact that the price of blueberry pies is higher than the average price of commercial fruit pies - all these factors influenced the initiation of studies of the feasibility of using some new potential processing methods. These studies were undertaken to determine the possibility of reducing cost of processing, storage, packaging and distribution, and therefore to increase the sales of the blueberry products. Two new processing technologies were considered in these studies, the dehydrofreezing process and the explosive-puffing process.

Objectives

The present study was designed:

- a. to review the trends in blueberry production, consumption, processing and utilization,

- b. to review the development of new fruit and vegetable processing technologies and their economic significance, and,
- c. to make a progress report on the feasibility of using products from two new processing methods for blueberries, the dehydrofreezing and the explosive-puffing, by determining consumer preferences of these two new product forms compared to standard forms.

Chapter III

THE BLUEBERRY INDUSTRY

A. Production and Importation

Blueberry production has been expanding rapidly. Significant changes in production are occurring in Michigan, New Jersey, North Carolina and Washington. While total blueberry production is increasing, the acreage harvested has also been increasing but at a slower pace. National yield per acre has exhibited an increasing trend since 1939. Both the average size and number of blueberry farms in the United States have been expanding. Total blueberry imports have shown a declining trend; however, imported blueberries in frozen forms have shown a rising trend. The United States blueberry industry is concentrated in Michigan and the eastern states, Maine, New Jersey, North Carolina and in Washington.

The United States blueberry industry has been expanding rapidly. In 1939 production amounted to 13.3 million pounds with a total farm value of about one million dollars.¹ By 1959, this had increased to 49 million pounds valued at about 11.4 million dollars. Over a period of 21

¹ L.C. French, "Trends in Blueberry Consumption," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, Vol. 40, No. 1, August 1957, p. 34.

years national production has increased by about 269 percent.²

Two types of blueberries are produced in the United States, the wild and the cultivated blueberries. Wild blueberries are small berries, untaxed and do not receive much care and are usually marketed fresh. The wild blueberry production has not been increasing in Canada and Maine as rapidly as the cultivated blueberries in the United States, because of shortage of harvesting labor and high cost required to clean the berries sufficiently to pass the requirements of the U.S. Department of Agriculture. The cultivated blueberry production has been increasing because the berries are easier to process and involves less freight cost as the cultivated berries are raised nearer the large consuming areas. The cultivated blueberries have more reliable quality and better consumer acceptance particularly in the fresh market. The cultivated blueberries are mostly grown in Michigan, New Jersey, North Carolina and Washington.

In 1929 Maine produced approximately 77 percent of the total U.S. blueberries in 1962 only 40%. Since 1949, Maine, New Jersey, and Michigan have produced over 80 percent of total U.S. blueberries annually. (See Table 3.1).

²U.S. Bureau of the Census, U.S. Census of Agriculture, 1954 to 1959.

From 1939 to 1959 blueberry production in Michigan increased from 1.04 million pounds to about 11.84 million pounds, an increase of 1030 percent. During this same period blueberry production in Maine increased by 76 percent, in New Jersey 1046 percent, in North Carolina 1764 percent and in Washington 4379 percent.³ (See Table 3.2). Production in these areas has increased significantly through efficient use of fertilizers, irrigation, better insect and disease control, better management, and consolidated ownership.

National blueberry acreage harvested had been increasing. In 1939 acreage harvested was about 31.3 thousand and in 1959 about 43 thousand acres, an increase of about 39 percent. Harvested blueberry acreage in Michigan increased from 2305 acres in 1939 to 5003 acres in 1959. During these same periods blueberry acreage harvested increased 24 percent in Maine, 793 percent in New Jersey, 1505 percent in North Carolina, and 2591 percent in Washington.⁴ (See Table 3.2).

The national blueberry yield per acre has also shown remarkable increases from 426 pounds per acre in 1939 to 1137 pounds per acre in 1959. The national average yield per acre in 1959 showed an increase of 167 percent over 1939.

³Ibid., Census of Agriculture, 1939-59.

⁴Ibid., Census of Agriculture, 1939-59.

Table 3.1. Blueberry Production in Ten States, Selected Years.

	1929/ Lbs.	Percent of Total	1939/ Lbs.	Percent of Total	1949/ Lbs.	Percent of Total	1954/ Lbs.	Percent of Total
Maine	5,716,209	77.00	8,608,530	64.70	13,332,442	53.37	17,223,946	37.50
New Jersey	274,281	3.70	1,103,929	8.30	6,790,462	28.00	13,060,462	28.40
Michigan	300,705	4.00	1,047,667	7.80	1,629,781	6.70	10,106,265	22.10
Massachusetts	182,341	2.50	454,185	3.40	83,320	.35	870,138	1.90
North Carolina	165	6/	174,484	2.00	501,799	2.00	1,578,547	3.40
Washington	2,400	.03	63,142	.50	672,535	2.80	815,812	1.70
Maryland	---	---	3,757	.02	125,892	.50	282,634	.60
Indiana	6,217	.08	108,162	.80	80,269	.03	346,543	.75
Others	---	12.62	---	12.48	---	6.25	---	3.65
U.S. Total	7,417,306	100.00	13,301,086	100.00	24,074,953	100.00	45,764,653	100.00

Table 1 (continued)

	1959 ^{a/} Lbs.	Percent of total	1960 ^{b/} Lbs.	Percent of total	1961 ^{b/} Lbs.	Percent of total	1962 ^{b/} Lbs.	Percent of total
Maine ^{c/}	15,169,659	31.00	21,336,422	29.00	25,550,157	37.29	30,092,017	40.15
New Jersey	12,649,690	25.80	25,410,000	33.00	16,214,000	23.65	19,216,000	24.14
Michigan	11,839,407	24.00	21,426,155	28.00	18,593,679	27.12	19,294,446	24.25
Massachusetts	613,507	2.00	---	---	---	---	---	---
North Carolina	3,244,665	6.60	4,895,000	6.00	5,170,000	7.54	5,995,000	8.00
Washington	2,823,022	5.80	2,875,000	3.00	2,995,000	4.37	2,650,000	3.00
Maryland	217,846	.50	---	---	---	---	---	---
Indiana	303,069	.80	---	---	---	---	---	---
Others	---	3.50	---	2.00	---	.02	---	.55
U.S. Total	49,022,851	100.00	75,573,577	100.00	68,512,735	100.00	75,437,563	100.00

^{a/} From 1920 to 1959: U.S. Bureau of the Census, U.S. Census of Agriculture.

^{b/} From 1960 to 1962: Blueberry Growers Association of Michigan. It includes only 5 states listed above.

^{c/} Blueberries harvested in Maine are mostly wild blueberries.

^{d/} Less than .01 percent.

In Michigan average yield per acre increased from 454.5 pounds in 1939 to 2367 pounds in 1959, a 420 percent increase.⁵ (See Table 3.2). The average yield per acre from 1939 to 1959 in Maine increased 42 percent, New Jersey 23 percent, North Carolina 1056 percent, and Washington 66 percent. In 1959 the average yield per acre of farms in Michigan, New Jersey, North Carolina and Washington were higher than the national average yield per acre.

The national average size of blueberry farms increased significantly from 6.2 acres in 1939 to 10.5 in 1959, a 69 percent increase. In Michigan the average farm size increased from 4.3 acres in 1939 to 6.9 acres in 1959, a 53 percent increase. During these same periods average farm size in Maine increased 73.6 percent, New Jersey 40.7 percent, in Washington 104 percent, while North Carolina decreased by 4 percent. In general the blueberry farms have been expanding both in number and in size.⁶ (See Table 3.2)

In 1959 the average farm size in Maine was largest, while in Washington the farms appeared to be the smallest. The average Michigan farm was smaller than the national average farm size.

From 1954 to 1962 total imported blueberries for consumption dipped from 33.5 percent to 11.9 percent of the total

⁵Ibid., Census of Agriculture, 1939-59.

⁶Ibid., Census of Agriculture, 1939-59.

Table 3.2. Total Blueberry Production, Acreage Harvested, Yield Per Acre, and Average Farm Size of Selected States in Selected Years, 1929-1959.

	Total Production	Acreage Harvested	Yield Per Acre	Ave. Size Per Farm
	Lbs.	Acres	Lbs.	Acres
U.S.				
1929	7,417,306	20,653	411	6.6
1939	13,301,036	31,276	426	6.2
1944	19,722,222	43,238	247	11.5
1949	24,074,953	30,801	780	9.2
1954	45,964,653	42,812	1,074	10.5
1959	49,022,851	43,094	1,137	10.5
Michigan				
1929	300,706	673	343.6	6.6
1939	1,047,667	2,303	454.5	4.5
1949	1,629,761	1,731	941.5	6.3
1954	19,106,265	4,167	2,245.9	7.3
1959	11,539,407	5,003	2,307	6.9
Maine				
1929	5,716,209	13,800	411	12
1939	8,603,530	20,136	427	11.4
1949	13,264,942	22,440	591	13.7
1954	17,223,946	26,500	649	12.4
1959	15,169,653	24,970	607	20.2

Table 2 (continued)

	Total Production	Acreage Harvested	Yield Per Acre	Ave. Size Per Farm
	Lbs.	Acres	Lbs.	Acres
New Jersey				
1929	154,281	121	1,273	10
1939	1,103,929	673	1,633	7.4
1949	6,690,462	4,879	2,539	7.6
1954	13,060,462	2,674	2,677	9.3
1959	12,648,690	6,030	2,097	10.4
North Carolina				
1929	1,650	1	165	.3
1939	174,494	119	146	19.6
1949	501,799	563	884	11.7
1954	1,579,547	1,121	1,408	14.6
1959	3,244,663	1,893	1,612	18.6
Washington				
1929	2,400	4	600	4.0
1939	63,139	23	2,745	1.3
1949	672,533	207	3,249	2.1
1954	819,872	434	1,880	2.1
1959	2,828,022	619	4,569	2.6

Sources: Bureau of the Census, Census of Agriculture: 1929 to 1959.

blueberries available in the United States.

United States importation of blueberries has shown a declining trend. Imported blueberries dropped from 25.67 million pounds in 1954 to 10.20 million pounds in 1962. This change represented 60.2 percent decrease in blueberry importation. (See Table 3.3)

A five-year average of blueberry imports for consumption decreased from 15.2 million pounds in 1953-57 to 11.5 million pounds in 1958-62. On the average blueberry imports declined 24.2 percent. Average frozen blueberry imports increased from about 3 million pounds in 1953-57 to 4.5 million pounds in 1958-62, a 51 percent increase in imported frozen blueberries; blueberries in brine decreased from about 11.9 million pounds to 6.7 million pounds, a decrease of 43 percent; prepared blueberries increased from about 2.4 million pounds to 2.6 million pounds, an increase of 13 percent. (See Table 3.4). Over the period 1958-1962, over 90 percent of U.S. blueberry imports originated from Canada. Other sources of blueberry imports include Poland, France, Yugoslavia, Sweden, Netherlands, West Germany, Italy and Norway. (See Table 3.5)

The largest blueberry importation occurred in 1954 when the United States imported 25.6 million pounds. Importation of blueberries which are mostly wild blueberries have been declining because U.S. production of cultivated blueberries has been increasing and these blueberries are easier

Table 1.1. U.S. Imports of Blueberries for Consumption, 1930-1962^a

	Total Imports	Frozen		Natural or in Brine		Preserved	
		Quantity	% of Total	Quantity	% of Total	Quantity	% of Total
	(1000 lbs.)	(1000 lbs.)		(1000 lbs.)		(1000 lbs.)	
1950	10,962	4,162	37.96	6,793	61.93	5	.06
1951	22,139	2,777	12.54	19,360	87.44	2	.02
1952	21,130	6,733	29.22	15,068	70.64	29	.14
1953	14,023	4,100	29.21	9,800	69.83	133	.96
1954	25,672	3,780	14.75	21,727	84.63	165	.62
1955	17,613	1,206	18.20	14,270	81.03	134	.77
1956	12,202	2,643	21.64	9,505	77.85	60	.51
1957	6,553	1,218	18.57	4,641	70.76	699	10.67
1958	10,999	2,075	18.86	8,192	74.33	742	6.76
1959	12,145	3,424	28.19	8,164	67.22	557	4.59
1960	14,119	6,165	43.66	7,939	56.23	14	.11
1961	10,194	5,610	55.03	4,560	44.73	24	.24
1962	10,203	5,363	52.60	4,826	47.29	11	.11

^a Bureau of the Census.

Table 1.4. Blueberry Imports: 5-Year Average, 1953-57 to 1958-62.

	Average Total Imports (1000 lbs.)	Average Frozen (1000 lbs.)	% of Total	Average in Brine (1000 lbs.)	% of Total	Average Prepared (1000 lbs.)	% of Total
1952-57	15,216	2,989	19.7	11,987.4	78.7	238	1.6
1958-62	11,532	4,523	39.3	6,734.6	58.4	269	2.3

Percent Change	-24.2	+51.5	-43.1	+13.0
-------------------	-------	-------	-------	-------

Source: U.S. Bureau of the Census.

to process, have more reliable quality and better consumer acceptance than wild blueberries.

B. Marketing

Fresh blueberries are on the market from early May to September. The peak supply is in July. The approximate percentage of total annual supply available by month nationally is: May 4 percent, June 24 percent, July 52 percent, August 13 percent, September 3 percent. The early season harvest comes from North Carolina; mid-season harvest from New Jersey; and late season harvest from Michigan. The season in any one locality usually lasts six to seven weeks. The harvesting season is relatively short so that each market is dominated by one state for a given period.

Michigan early blueberry varieties are marketed locally. While during the peak harvest of the main crop in July and in August, the berries are shipped long distances to many markets.

Fresh blueberries available on the market in Michigan in June come primarily from New Jersey and North Carolina and in early July from New Jersey. Few blueberries from other areas are shipped to Michigan at the peak of Michigan season.⁸

Blueberries sold in fresh form are principally cultivated blueberries from Michigan, New Jersey, and North Carolina.

⁸"Blueberries," Food Market Topics, Michigan State University, June 9, 1961, p. 2.

Table 1.1. Sources of U.S. Blueberry Imports, 1958-1962.

Country	1958	1959	1960	1961	1962
Pounds					
Canada ^{a/}	9,516,720	11,184,613	11,435,340	9,359,154	9,295,879
Poland		168,150	43,972	717,500	776,661
France	89,940	30,000	332,672	58,170	81,110
Yugoslavia		22,050			44,092
Sweden	304,540	125,500	271,080		
Netherlands	88,752	22,396		30,000	
West Germany	10,709				
Italy	247,268	36,000	29,250		
Norway			5,512		
Total	10,257,409	11,569,709	14,104,315	10,170,336	10,194,742

Sources: National Canners Association, Division of Statistics and Economics.

^{a/} In 1958, 1959, 1960, 1961, and 1962, Canada supplied 92.8 percent, 96.3 percent, 95.2 percent, 92 percent, and 91.1 percent of all U.S. blueberry imports, respectively.

These three states supply about 95 percent of the blueberries going to fresh market. (See Table 3.6). Consumption of fresh blueberries is concentrated near the area of production. Over 80 percent of the unloads of fresh blueberries were reported in 5 cities, New York, Boston, Philadelphia, Detroit, and Chicago, and 95 percent in these and 5 additional cities. (Table 3.7 and Chart 1). These data suggest that most blueberries are consumed in a relatively small part of the country and that a large part of the nation's population is not regularly exposed to fresh blueberries even during the principal season of fresh marketing.

The harvest seasons are short and one state at a time tends to dominate the market in most seasons, although the marketing season of the different areas may overlap. Even with a fairly high degree of market management by growers and their organization, frequently, periods of over supply and depressed prices in terminal cities exist.

C. Consumption

Total blueberry consumption in 1929 amounted to 13.2 million pounds, 1939, 18.7 million pounds, in 1949, 49.0 million pounds. In 1959 and 1962, total blueberry consumption amounted to 61 million pounds and 85.6 million pounds, respectively. From 1929 to 1962, total blueberry consumption increased about 548 percent.⁹ (See Table 3.8)

⁹ S. C. French, "Trends in Blueberry Consumption," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Mich., Aug. 1957, Vol. 40, No. 1, p. 35. Also Bureau of the Census, Census of Agriculture, 1954 & 1959. Production figures from 1960 to 1962, obtained from Blueberry Grower's Association of Michigan.

Table 1.6. Origin of Fresh Blueberry Unloads Reported in Ten Terminal City Areas, as a Percentage of Total Unloads, 1958 to 1962.

Origin	1958	1959	1961	1962
(Percent of Total Unloads)				
North Carolina	18.1	20.9	12.4	13.0
New Jersey	56.2	60.3	59.2	59.6
Michigan	20.2	15.0	24.8	23.5
Illinois	0.1	0.1	-----	0.3
Maryland	0.3	1.0	0.3	0.6
Massachusetts	1.7	1.0	1.2	1.9
Maine	0.2	0.1	0.1	-----
New York	0.1	-----	0.1	0.1
Ohio	0.3	0.2	0.3	0.1
Pennsylvania	1.1	0.9	-----	-----
Virginia	-----	0.1	-----	-----
Washington	-----	0.1	-----	-----
South Carolina	-----	-----	1.4	0.7
Canada	1.3	0.7	0.3	0.2
	-----	-----	-----	-----
Total	100.0	100.0	100.0	100.0

Sources: Data for 1958-1959: George T. McCloskey, "A Look At Blueberry Market," Blueberry Research, Fifty Years of Progress, New Jersey Agricultural Experiment Station, Rutgers, July 1960, p. 27.

Data for 1961 and 1962: U.S. Department of Agriculture, AMS, Fresh Fruits and Vegetable Unloads, 1961 and 1962.

Table 2.7. Blueberry Unloads Reported in 18 Terminal City Areas, 1957-1962.

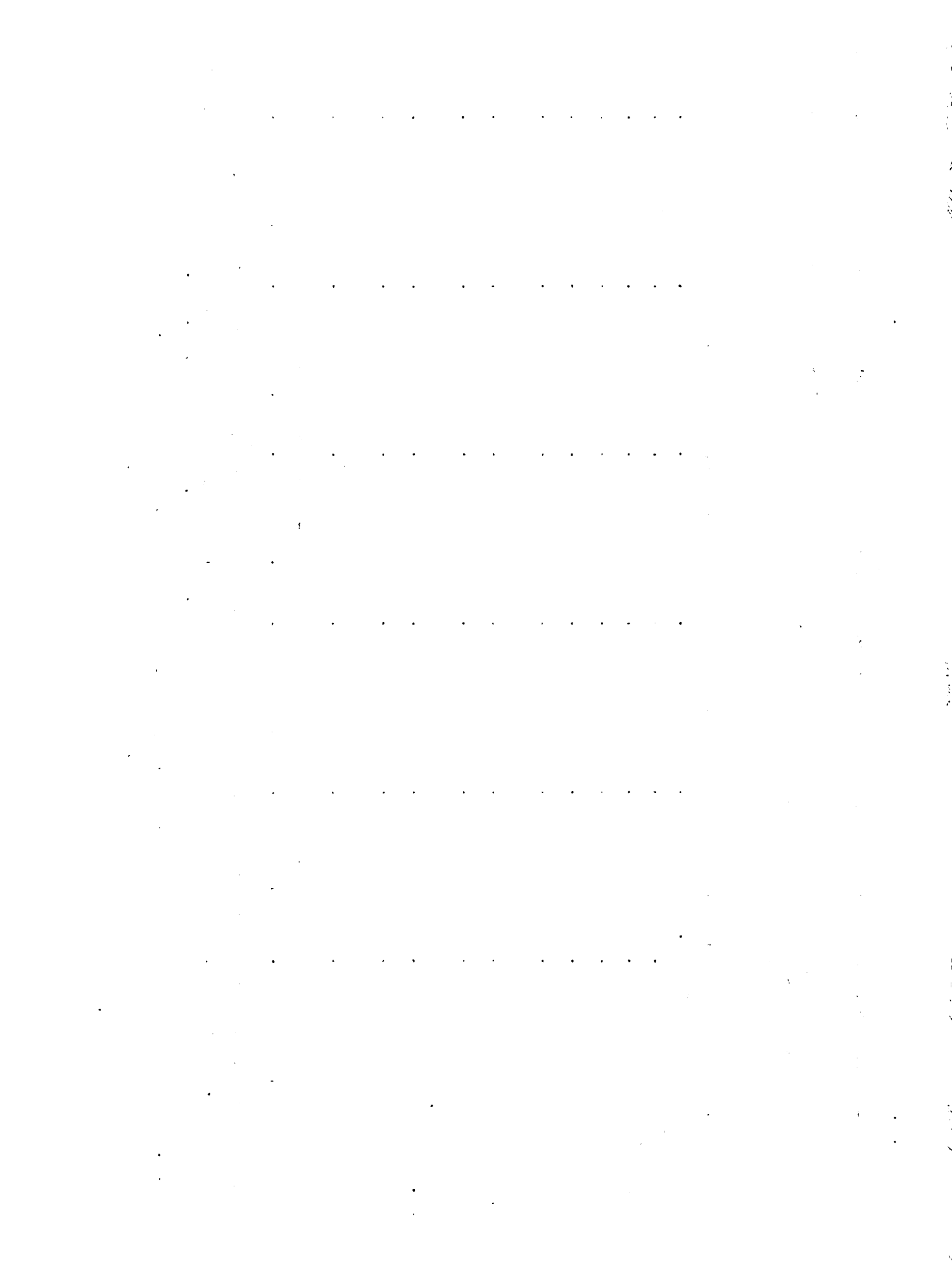
City	1957 ^a		1958 ^a		1959 ^a		1960 ^a		1961 ^a		1962 ^a	
	Number of Total	Percent of Total	Number of Total	Percent of Total	Number of Total	Percent of Total	Number of Total	Percent of Total	Number of Total	Percent of Total	Number of Total	Percent of Total
New York/Newark 472 ^b	43.8	529	43.4	445	42.5	703	47.5	559	42.5	609	42.6	
Boston	145	13.4	155	12.8	151	14.4	178	12.0	184	14.0	113	8.2
Philadelphia	117	10.8	136	11.2	119	11.4	173	11.7	141	12.7	171	12.2
Detroit	125	11.7	110	9.0	81	7.7	109	7.4	98	7.5	109	7.8
Chicago	103	9.6	130	10.7	99	9.4	123	8.3	124	9.4	142	10.2
Cleveland	31	9.6	36	3.0	34	3.2	43	3.2	41	3.1	45	3.2
Minneapolis-St. Paul	29	2.7	34	2.8	33	3.1	42	2.8	46	3.5	59	4.2
Baltimore	19	1.8	29	2.3	22	2.1	36	2.4	36	2.7	42	3.0
Washington, D.C.	2	.2	22	1.8	27	2.6	27	1.8	31	2.4	29	2.0
Cincinnati	16	1.5	14	1.2	10	1.0	20	1.4	13	1.4	21	11.5
Eight Other Cities ^c	17	1.6	22	1.8	27	2.6	22	1.5	36	2.8	56	4.1
Total	1,077	100.0	1,217	100.0	1,048	100.0	1,481	100.0	1,314	100.0	1,397	100.0

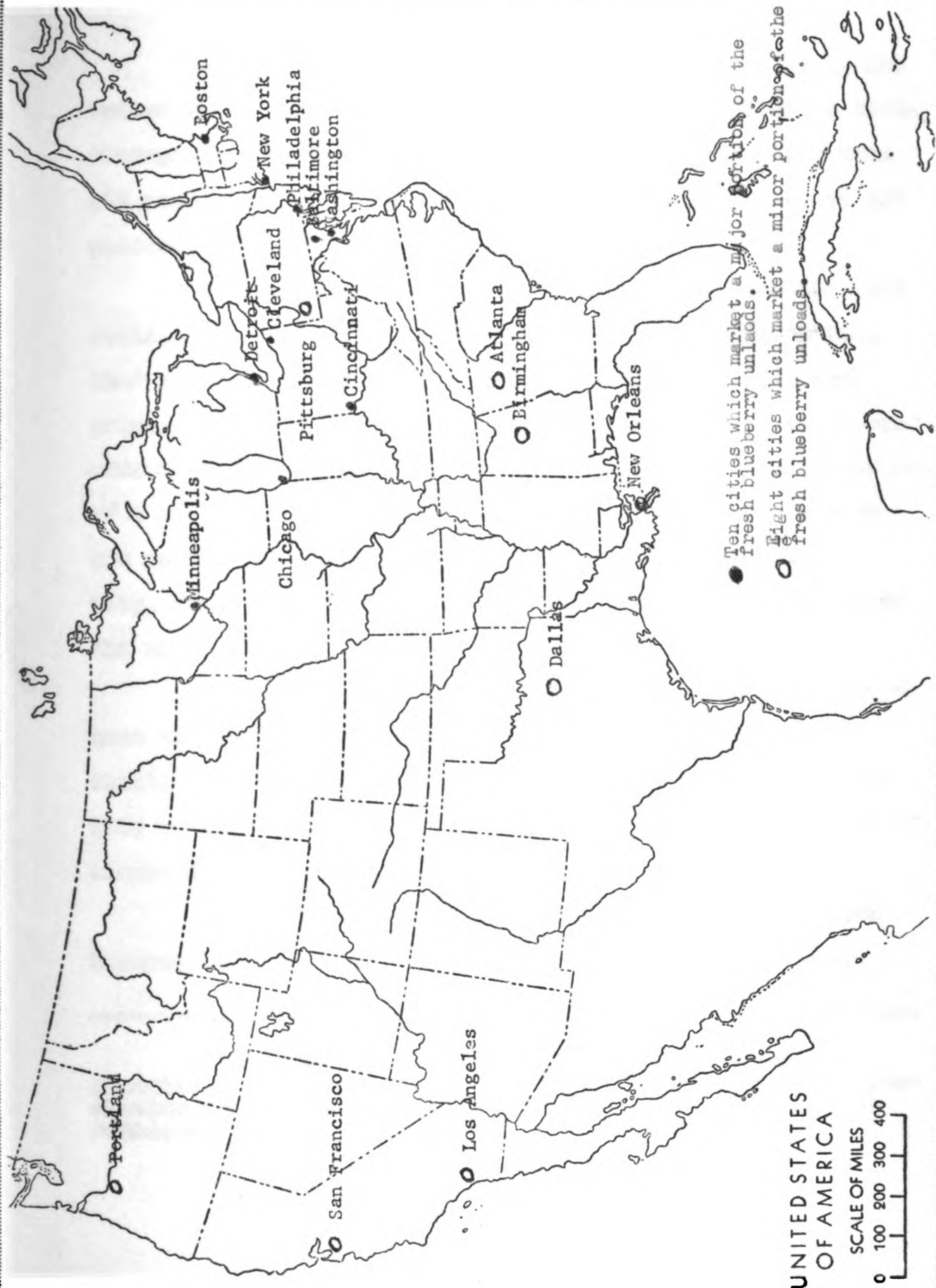
^a George T. McIlwain, "A Look at the Blueberry Market," Blueberry Research, Fifty Years of Progress, New Jersey Agricultural Experiment Station, Rutgers, July 1960, p. 26.

^b U.S. Department of Agriculture, A-2, Fresh Fruits and Vegetable Unloads.

^c Carlot is considered equivalent to 1,400/2 pint berry crates.

^d Excludes Newark.





Average per capita consumption of blueberries in the United States also increased significantly from 1929 to 1962. Average per capita consumption increased significantly from .11 pounds in 1929 to .46 pounds in 1962, an increase of 313 percent.¹⁰

At present, there are few blueberry consumption data available. French, in his study of blueberry consumption, used the Michigan State University consumer panel as the principal source of consumption information. The panel was made up of about 250 urban families selected as representative of a Michigan city of about 100,000 population. Each week the panel families reported in an itemized diary the quantity, price, and amount paid for each item of food purchased for home consumption during that week.

French reported that in Michigan total home consumption of blueberries and blueberry products by the panel families averaged about 1.5 pounds per person per year from 1952 to 1956. The average rate of increase in consumption of blueberry was .1 pound per person per year.¹¹

The average annual per capita consumption of fresh blueberries (1952-1953) by panel members was .82 pounds.

¹⁰ Computations were based on: (a) production data reported in the Census of Agriculture, 1930 to 1959, (b) production data furnished by Blueberry Growers Association of Michigan.

¹¹ Op. cit., French, p. 35.

Table 3.3. Blueberries: Total and Per Capita U.S. Consumption in Selected Years.

Year	Total Consumption (million pounds)	Capita Consumption (pounds)
1929	13.2 ^a	.11
1939	18.7 ^a	.14
1944	19.4 ^a	.14
1949	49.0 ^a	.33
1954	72.8 ^a	.44
1959	61.2 ^b	.35
1960	89.7 ^b	.50
1961	78.7 ^b	.43
1962	83.6 ^b	.46

^a B.C. French, "Trends in Blueberry Consumption," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, August 1957, Vol. 40, No. 1, p. 33.

^b 1959 production and import data from U.S. Bureau of the Census, Census of Agriculture 1960-62 production data from estimates of Michigan Blueberry Growers Association and import data from U.S. Bureau of the Census, U.S. Census of Agriculture.

commercially processed pie, .6 pounds; canned, .33 pounds; and frozen, .04 pounds.¹²

A little over 54 percent of the MSU consumer panel members purchased blueberries in fresh forms, 43 percent purchased commercially processed blueberries and 23.8 purchased canned blueberries.¹³ Important upward trends appeared in the percent of families buying pie fillings and jellies.

Shaffer indicated that annual per capita expenditure on all fruits ranged from \$19.29 to \$24.36 between 1952 and 1953. In the same period annual per capita blueberry expenditure ranged from 24 cents to 33.5 cents, however, blueberry expenditure has shown an increasing trend.

Per capita expenditure on pie mixes and fresh blueberries showed an increasing trend but expenditure on frozen and canned blueberries showed a slightly declining trend.

On the average, blueberry expenditure amounted only to 1.33 percent of total expenditure on fruits. (See Table 3.9).

D. Blueberry Pie Compared to Fruit Pies

The use of blueberry pie filling has shown a remarkable increase in spite of the fact that the average prices of blueberry pies have been higher than that of any fruit pies.

¹² *Op. cit.*, French, p. 37.

¹³ *Op. cit.*, French, p. 38.

Table 3.9. Annual Per Capita Expenditure of Blueberries in Various Forms, 1952 to 1959.

Year	Per Capita Expenditure						% of			
	Blue-berries		Frozen		Canned		All		Fresh	
	1952	1953	1954	1955	1956	1957	1958	1959	Frozen	Canned
1952	19.290	.240	.132	.002	.102	.001	1.244	55	.833	42.5
1953	22.502	.300	.185	.001	.111	.000	1.333	61.66	.333	37.0
1954	22.288	.773	.177	.015	.080	.001	1.224	64.83	5.490	29.30
1955	24.360	.305	.260	.013	.109	.003	1.580	67.53	3.376	28.31
1956	23.276	.136	.220	.014	.069	.007	1.443	68.47	4.166	20.23
1957	22.885	.346	.240	.001	.072	.005	1.511	71.96	.209	20.80
1958	22.841	.378	.277	.000	.971	.002	1.654	71.28	---	18.78
1959	22.841	.378	.277	.000	.971	.002	1.654	71.28	---	18.78
Expenditure as a Percentage of Expenditures of Fruits: 1955-57 Averages:										
	100.0	1.33	.92	.05	.25	.04	.97			

Source: J. D. Schaffer, Consumer Purchase Patterns for Individual Fruits and Vegetables, MSU Consumer Panel 1952-1959, Consumer Panel Bulletin No. 8 (Michigan State University), 1962, p. 2.

The data above are based upon reports from MSU consumer panel. A group of approximately 275 families selected to be representative of Lansing, Michigan, a city of about 100,000 population. Each week panel families reported in an itemized diary, the quantity, price and amount paid for each item of food purchased for home consumption during that week.

From 1955 to 1962, blueberries used in commercially prepared pie increased from about 5.5 million pounds to about 8.3 million pounds, an increase of 60 percent.¹⁴ Great interest is placed upon blueberries in pie form because of the potential outlet for blueberry products.

On the average, apple and cherry pie accounted for 65.6 percent of all fruit pie purchased by each person, while blueberry pie accounted for a little over 10 percent.¹⁵

More and more families are purchasing commercially prepared apple and cherry pie. On the average, 37 percent of families purchased commercially prepared apple and cherry pie, while only 22.4 percent of families bought commercially prepared blueberry pie.¹⁶

From 1953 to 1957 the prices of all types of fruit pie averaged 38 cents per pound. The price of blueberry pie was consistently above the prices of the other fruit pies and the average price for all fruit pie. Blueberry pie price averaged 42 cents per pound between 1953 and 1957.¹⁷

¹⁴Canner Packer Yearbook, 1960-1962.

¹⁵H.C. French, "Some Economic Aspects of Pie Consumption," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, Vol. 41, No. 3, February 1959, p. 491.

¹⁶Ibid., p. 474.

¹⁷Ibid., p. 498.

Based on the average price and quantity, a 10 percent change in the average price of fruit pies was associated with a 21 percent change in quantity consumed in the opposite direction.¹³

If we assume that the demand for blueberry pies is also elastic, this would suggest that if the price of blueberry pies can be reduced to a level comparable to other fruit pies, increase in blueberry pie consumption is likely to occur.

There appears to be an excellent possibility of expanding the blueberry market. This is indicated by four factors: (a) blueberry consumption by panel families was about three times the U.S. average, (b) only 40 percent of the families used blueberries in some form or another more than twice a year, (c) an upward trend appeared in the percent of families buying pie fillings and jellies, and percent of families buying commercially prepared increased substantially from 1933 to 1934. About 10 percent of people purchasing commercially prepared pies purchase blueberry pies while 65.6 percent purchase apple and cherry pies, and (d) if the price of blueberry pies can be reduced to a price comparable to other fruit pies, such as apple and cherry pies, it is likely that blueberry pie purchases will increase.

E. Blueberry Processing

¹³ ~~Table~~ p. 497.

U.S. processing of blueberry crop dipped from 82.9 percent of the total crop in 1954 to 64.3 percent in 1962. However, the total volume of blueberries processed increased from 27,009,000 pounds in 1950 to 43,551,000 pounds in 1962, an increase of 79 percent. (See Table 3.10).

The total volume of U.S. processed blueberries has exhibited a slightly rising trend over 13 years, but total blueberry production has increased at a more rapid rate. This explains the decline in the percent processed out of the total blueberry crop from 1954 to 1962. (See Table 3.10)

From 1950 to 1962, U.S. canned blueberries dipped from 16.2 million pounds to about 13.2 million pounds, a decrease of 18.3 percent. In 1954 about 43 percent of the total blueberries produced in the United States was canned and in 1962 only 17.3 percent was canned. (See Table 3.10). From 1950 to 1962 frozen blueberries increased from 10.9 million pounds to 26.5 million pounds. Frozen blueberries increased 142 percent within the past 13 years. (See Table 3.10)

As a percentage of the total blueberry production, frozen berries decreased from 45.6 percent in 1954 to 33 percent in 1962. However, from 1959 to 1962 frozen blueberries, as a percentage of total production increased from 21.4 percent to 35 percent. (See Table 3.10). In 1950 about 40 percent and in 1962 about 54 percent of total processed blueberries was in the form of frozen berries. (See Table 3.11).

Table 3.10. Total Production and Processing of U.S. Blueberries, Selected Years.

Year	Total Production (000 lbs.)	000 lbs.	% of Total Crop	000 lbs.	% of Total Crop	000 lbs.	% of Total Crop	000 lbs.	% of Total Crop
1949	24,075 ^a		14,000	58.2	18,899				
1950		27,099		10,900		16,199			
1951		38,899		13,900		24,999			
1952		23,966		9,000		14,966			
1953		30,599		14,000		16,599			
1954	45,965 ^a	40,866	88.9	21,000	46.6	19,866	43		
1955		43,132		21,000		16,633		5,499	
1956		37,932		19,600		10,133		8,199	
1957		46,332		24,400		15,899		6,033	
1958		34,598		16,000		11,599		6,999	
1959	49,023 ^a	37,463	76.4	16,400	33.4	12,566	25.6	8,499	17.4
1960	75,574 ^b	44,528	58.9	25,230	33.4	10,999	14.5	8,299	11.0
1961	66,513 ^b	43,089	62.8	21,990	32.0	12,433	18.2	8,666	12.6
1962	75,438 ^b	48,551	64.3	26,452	35.0	13,233	17.6	8,866	11.7
4-year Ave. (1959-62)	67,136	43,488	64.6	22,518	33.5	12,307	18.4	8,582	12.7
								23,728	35.4

Source: ^a Production data from U.S. Bureau of the Census, U.S. Census of Agriculture.
^b Production data from estimates of Michigan Blueberry Growers Association.
^c Canner Packer yearbook, 1960-62.

Table 3.11. Proportion of U.S. Processed Blueberries in Canned, Frozen, and Pie-Filling Form, 1950-1962.

	% Canned	% Pie Filling	% Frozen
1950	59.8	---	40.2
1951	64.3	---	35.7
1952	62.4	---	37.6
1953	54.2	---	45.8
1954	48.6	---	51.4
1955	36	13.3	50.7
1956	26.7	21.6	51.7
1957	34.3	13.0	52.70
1958	33.1	20.2	46.7
1959	33.5	22.7	43.8
1960	24.7	13.6	56.7
1961	20.8	20.1	51.0
1962	27.3	16.3	54.4

Computed from Table 5.

During the period 1959 to 1962 approximately 33 percent of the U.S. blueberry crop (21.75 million pounds) was used in fresh form, while 65 percent (41.4 million pounds) was used in processed form. Of the 41.4 million pounds processed, about 52 percent was frozen, 23 percent canned, and 20 percent was used as canned pie filling. (See Table 3.10)

Most of the blueberries grown in Maine and in Canada are wild blueberries while those grown in Michigan and New Jersey are cultivated blueberries. Most of the wild berries, which are normally of smaller size, are processed, while a larger proportion of the tame or cultivated berries are marketed fresh. During 1960-1962 approximately 99 percent of the Maine blueberry crop was processed, while about 53 percent of the Michigan crop and 33 percent of the New Jersey crop was processed. Practically all of the U.S. imports of Canadian blueberries are processed forms of "wild" blueberries.

The proportion of the blueberry crop processed in Michigan has remained relatively stable at approximately 50 to 53 percent of the crop. In New Jersey the proportion processed decreased from 39 percent of the crop in 1960 to 23 percent in 1962.

In 1960 there were 16 firms processing blueberries in Michigan, with 20 plants involved in processing.¹⁹

¹⁹ Food Market Topics, Marketing Information for Consumer Program, Michigan State University, June 9, 1961, p. 6.

About 95 percent of the frozen blueberries go into the institutional pack (30-pound tins). All institutional pack is frozen and then diverted to by products such as pie fillings and muffin mixes. About 60 to 70 percent of the processed blueberries go into pies.²⁰

Approximately 5 percent of the processed berries are sold in retail size packages for consumers. The blueberries in consumer packages have skins that appear to be tough but actually are no tougher than in the fresh berries. However, the interior of the frozen berries is softer after freezing. This gives a greater contrast to the texture of the skin. For these reasons, consumer packages of frozen blueberries have not been too well accepted.²¹

Among the uses for processed blueberries are, blueberry pies, muffins, pancakes, sauce, coffee ring, cheese pie, Minadnock pudding, cheese dressing, short cake, cream puffs and blueberry marmalade. Blueberries are also processed into syrup, honey, jams, jellies and juice.

F. Summary

In a brief summary, the production of blueberries in Michigan and nationally, has increased significantly over the

²⁰ ~~ibid.~~, p. 6.

²¹ Personal communication with Dr. C.L. Bedford, Food Science Dept., M.S.U.

past three decades. Over 90 percent of the U.S. blueberry crop is produced in 5 states: Maine, New Jersey, Michigan, North Carolina, and Washington.

Total blueberry imports have shown a declining trend; however, imported blueberries in frozen forms have shown a rising trend.

Blueberries sold in fresh form are principally cultivated blueberries from Michigan, New Jersey, and North Carolina. These three states supply about 95 percent of the blueberries going to fresh market. Consumption of fresh blueberries is concentrated near the point of production. Over 80 percent of the unloads of fresh blueberries were reported in five cities, New York, Boston, Philadelphia, Detroit, and Chicago, and 95 percent in these and 5 additional cities.

Total and per capita consumption of both fresh and processed blueberries is increasing and consumption of fresh blueberries is concentrated relatively near to areas of production.

Over half of the total blueberry crop is processed and the principal uses of the processed products are in pies and in blueberry muffins.

Chapter IV

DEVELOPMENT OF FOOD PROCESSING TECHNOLOGIES

A. INTRODUCTION.

As one of the objectives of this thesis is to "make a progress report on the feasibility of using products from two new processing methods for blueberries," the dehydrofreezing and explosive-puffing process, it is considered desirable to discuss these technologies in a brief historical perspective with other food processing methods applicable to fruits and vegetables. The following brief review will serve two purposes, first, to show where the new technologies fit in the spectrum of all processing technologies and also to show the advantages and disadvantages of the new technologies compared to other currently possible technologies.

In the very recent past several new food processing technologies have been developed. Among these are: dehydrofreezing, explosive-puffing, freeze-drying, vacuum concentration with essence recovery, vacuum drying, flake drying, foam mat drying, commercial irradiation and sonic drying.

Products from two new processing technologies, dehydrofreezing process and explosive-puffing process were considered in this study to determine their applicability to blueberries. The freeze-drying process and other processes were not considered in this study mainly because at the present stage of development, high cost of processing is involved, and because

of the limited amount of funds and time available to conduct similar studies using the other methods of processing. Foam mat drying and spray drying are primarily adopted to purées or juices and thus were not applicable to the principal use forms of blueberries. Vacuum drying, while applicable to whole blueberries is at the present time a high cost processing technique. Thus of all the new processing technologies which might be applicable for blueberries, at the present stage of development, dehydrofreezing and explosive-puffing appeared to be the most appropriate.

Dehydrofreezing is a recently developed technology which reduces the weight and volume of the product while the quality is maintained. It combines dehydration and freezing techniques. Another newly emerging food processing technology is the explosive-puffing process. This is an improvement of the normal dehydration process and offers better processed products than the normally dehydrated products. The product processed by the explosive-puffing process is termed "quick-cooking" dehydrated products. This process can be operated at relatively low cost, applied to relatively large pieces of fruits and vegetables and produce products capable of rapid rehydration. This process is a very recent development and has been tested on very limited fruits and vegetables.

It is evident from history that the technology of food processing is turning back to the methods of drying. This has been mainly the result of increasing freight rates,

expensive storage cost, high packaging outlay, increasing specialization in production areas that increases the gap between the area of production and the market for the products, hotel, institutional and consumer demand for convenience food products. There exists a continuing search throughout the world for new methods of processing which may yield high quality dried products, products which can be preserved at relatively low cost, products that may be distributed cheaply, and products that may offer convenience not only to institutions and hotels, but also to consumers.

B. Dehydration

Dehydration is probably the oldest method of food preservation. In the early colonial days dehydration was used to preserve fruits and vegetables. Apples were dried in considerable quantities. Along the coast, drying of fish was common. In many parts of the country, fruits, vegetables and meat were preserved by drying. The Indians and later the settlers preserved buffalo meat by cutting it into thin strips and hanging the strips up for the sun and wind to remove the excess moisture.¹

According to Prescott and Sweet when gold was discovered in the Klondike, the gold rush created a demand for

¹Prescott and Sweet, "Commercial Dehydration: A Factor in the Solution to the International Problems," Ann. Am. Acad. Political and Social Science, No. 1294, 1919, p. 48.

foods which were light and could easily be transported. Dried potatoes were imported from Germany and were rehydrated by soaking in water. They were served in the form of hashed or fried potatoes. The reconstituted potatoes, however, were not very palatable but quickly supplied the necessary ration for the mines.²

Shortly after the dried potatoes were used by miners in the Klondike, dried potatoes were manufactured in Oregon and Washington. The manufacturer, however, used sulphur to prevent the darkening of the slices of potatoes before drying. The amount of sulphur used was so much that the taste and odor when cooking were very unpleasant. This problem was shortly overcome. The Boer War (1901-1902) and the European War (1914-1918) stimulated the dehydration industry. In as much as large quantities of food stuff was needed to feed the armies during these wars, the need to study careful preservation of food supply occurred.

In the recent past various research work has been done on dehydration as a means of protecting fruits and vegetables against spoilage and for future use.

Many foods are now processed in powder form. Onions, garlic and other seasoning powders are ground from dehydrated pieces. Milk powder is processed in a number of ways. Potato

²*Ibid.*: p. 49.

flour is ground from drum-dried sheets of potato solids. Cereal flour and instant coffee are other examples of food in powder form.³ The process of dehydration was developed out of the need to preserve food against spoilage and for future use. In the early stages of developing dehydration, some dehydrated products were not very palatable, the products darkened and an unpleasant odor was produced. At present, numerous dehydrated food products have been found acceptable by consumers.

C. Canning

In 1804 Nicholas Appert, an expert confectioner, brewer and distiller, discovered the art of canning. He preserved his products in glass bottles, adding sufficient water to cover the product and inserted the corks. Later he placed them in a water bath. The bottles were heated gradually.⁴

In 1807 Peter Durrand, known as the father of the tin can, obtained a patent for preserving meat, fruits and vegetables in tin cans.⁵

³M. J. Copley, V. F. Kaufman, and C. L. Rasmussen, "Recent Development in Fruits and Vegetables Powder Technology," Food Technology, 10, 1956, p. 604.

⁴A. W. Bittling, and E. G. Bittling, Canning and How to Use Canned Foods, National Cannery Association, Washington, D. C., (printed by Nat. Capital Press, Inc., Washington, D. C.), 1916, pp. 11-12.

⁵Oliver Powell, Successful Canning and Preserving, Philadelphia & London: J. B. Lippincott Company, 1918, pp. 1.

Guy Lucas, a foremost chemist at that time, investigated the real cause for keeping of canned food. However, it was Pasteur who discovered most of the fundamental principles involved in the preservation of food by canning.

According to Powell⁶ in 1219 Ezra Baggett, a packer of salmon, lobster and oysters in New York, established the canning industry in the United States. In 1321, William Underwood packed preserves and table condiments in glass and by 1335 he packed tomatoes in glasses. The growth of the canning industry was rapid. Numerous canneries sprang up in various parts of the country.

In 1393 Prescott and Underwood⁷ were the first two scientists to apply the science of bacteriology to canning.

Many research projects have been done to improve the canning industry. Methods of determining heat penetration on canned products and determining the resistance of spores of known spoilage bacteria have been developed. Research work has been extended to the study of the quality of the finished product which primarily depends on the quality of raw materials. Extensive studies have been undertaken in the retention of nutrients, tin plates, can manufacture, and factors governing corrosion.

⁶ Ibid., p. 4.

⁷ Fred Stare, The Story of Macdonald's Great Canning Industry, Baltimore, Maryland: The Canning Trade, Nov., 1949, p. 21.

Although extensive studies have been undertaken to improve the canning industry, still there remains more to be done in maintaining the appearance and flavor of fruits and vegetables through the canning process.

D. Freezing

In the olden days farmers, trappers and fishermen in cold regions where long cold winter prevailed preserved food in unheated buildings.

In the Great Lakes fish was frozen by allowing it to remain in the ice. However, commercial freezing of food in the United States began in 1865 by placing salt and ice around the fish container. Later, ammonia refrigeration machines were used to freeze fish.

In the early 1900's, small fruits for making preserves, jams, jellies, pies were frozen for later use in the eastern part of the United States.

The Birdseye organization started commercial freezing of vegetables in 1929. During the past 30 years, production statistics have shown that the frozen food industry has grown rapidly. Clarence Birdseye predicted that the quality of frozen foods would be equivalent in quality to fresh foods if great care is taken in the selection, handling, preparation, freezing, storage, transportation and marketing of unprocessed food products.

In 1953-54 over half of the oranges in Florida were converted into juice, concentrated and frozen.

Prepared and pre-cooked foods are increasingly coming out of the market. Chicken pies, beef pies, fruit pies, plate dinners are becoming popular.

Statistics have shown that the annual per capita consumption of frozen fruits and vegetables has expanded while that of canned and fresh fruits and vegetables have declined.⁸

L. Freeze-drying

Freeze-drying, a recently developed method of food preservation, enables bulk handling of products, eliminates the handling of trays, simplifies loading and unloading of the dryer, provides uniform drying of products, and avoids troublesome wet spots.⁹

Several steps are involved in freeze-drying food. Foods must first be preserved as frozen food. Cooking the food may be a preparatory step before freezing. Freezing the food is the next step. Then the frozen product is dried under vacuum. In the freeze-drying process, the moisture content is changed directly from the solid form to a gaseous form without having undergone the intermediate liquid stage. Obviously, the above step involves not only freezing but also drying. These steps make freeze-dehydration more costly than

⁸Tressler and Evers, op. cit., p. 23 and 24.

⁹A. I. Morgan, Jr., and V. F. Kaufman, "Tumbling Freeze-Dryer Promises Advantages," Food Engineering, November 1962, p. 106.

preparing frozen foods. Therefore, to use freeze-drying processes foods, it is necessary that some advantages be gained over the ordinary freezing method to justify the extra expenditure on the dehydration process.

Freeze-dried foods have longer shelf life at ambient temperature than many frozen or canned foods. Quality deterioration is slower in freeze-dried foods than frozen foods. Because of the weight saving of approximately 70 to 80 percent in freeze-drying process, a remarkable saving in transportation cost is also realized which makes freeze-drying process look economically feasible for some products.

Freeze-drying is a new method of food processing, but it is not always applicable to all products. It is generally limited to products which cannot be dehydrated successfully by cheaper methods.

The disadvantages of freeze-drying are:

- (1) relatively high cost of equipment,
- (2) processed product has a large surface exposed because no shrinkage takes place,
- (3) freeze-dried foods are friable and may easily result in breakage and powdering.
- (4) volume is not reduced, thus, there is no space savings in storage.

Some freeze-dried products have been tested for general acceptability, appearance, flavor, texture, and tenderness. The present quality of the freeze-dried foods, according to

Maguire, is excellent and steadily improving as proven by qualified test panels.¹⁰

The Armed Forces Food and Container Institute has launched an extensive research in freeze-drying, and, has developed 21 menus using freeze-dried eggs, fruits, vegetables and meat.¹¹

At the present time, due to the high cost of freeze-drying, freeze-drying was not considered to be an appropriate technology for blueberries to be used in pie or in muffin mixes, particularly if the explosive-puffing and dehydrofreezing would yield acceptable products as both of these latter technologies would be cheaper than freeze-drying.

F. Dehydrofreezing

After the conventional freezing procedure, dehydrofreezing evolved. It is a method of food preservation where food is partially dehydrated prior to packaging and freezing. This method retains the advantages of both dehydration and freezing and partially eliminates the disadvantage of each.

Thus dehydrofreezing, which involves drying the commodities to approximately 50 percent of fresh weight¹² before

¹⁰J. F. Maguire, "Freeze-drying Moves Ahead in U.S.," Food Engineering, August 1962, p. 34.

¹¹A. C. Rauch, "Government Programs for Freeze-Dried Foods," Food Processing Review, Oregon State University, December 7, 1962, p. 23.

¹²Tressler and Evers, op. cit., p. 142.

packaging and freezing, will preserve the freshness and reduce weight and volume considerably.

Dehydrofreezing is a relatively new method of food preservation. Studies have revealed that this method has economic advantages over some known methods of food preservation. Studies have also shown that dehydrofrozen fruits and vegetables have gained consumer acceptance.

Rasmussen, et al. pointed out that the main advantage of dehydrofreezing is the reduction of weight and bulk of the product while quality is maintained. It was also estimated that if all the peas in 1956 were packed in institutional containers, a saving of 3 to 4 million dollars would have been realized.¹³

Reduction in weight and bulk, reduction of drip in thawing and the ease of controlling the moisture are the advantages of dehydrofrozen products over frozen items. As a result of the reduction in weight and bulk, packing, storage and shipping costs are reduced.

Dehydrofrozen products offer some advantages over dehydrated items. Dehydrofrozen are easier and better to rehydrate; flavor, texture, and color are superior.

¹³C. L. Rasmussen, D.W. Venstrom, H.J. Newman, R. L. Olson, W.C. Rockwell, and K. Strong, "Latest Dehydrofreezing Cut Costs," Food Engineering, December, 1957, p. 117.

Kaufman, et al., indicated that though plant investments for dehydrofreezing is higher than for freezing, primarily due to the difference in drying facilities, this difference in the long run is more than offset by the reduction in cost of packaging and freezing.¹⁴ In apples packaging cost may be reduced by packaging a greater weight of apples in containers of a given size and by using low cost containers since no liquid drains from the slices.¹⁵

Copley estimated that the cost of containers, storage, and transportation for dehydrofrozen green peas was 50 percent lower than that of frozen peas and about 53 percent lower than that of canned peas. These results were based on Table 4.1.¹⁶

A research project conducted by Boggs and Talburt revealed that frozen and dehydrofrozen peas were equivalent in fresh quality of fresh pods, but small losses of sugar and ascorbic occurred in both frozen and dehydrofrozen.¹⁷

¹⁴V.F. Kaufman, and M.J. Powers, "How Dehydrofrozen Cuts Packaging Shipping Costs on Processed Fruit," Food Engineering, January 1947, p. 96.

¹⁵W.F. Talburt, L.H. Walker, and M.J. Powers, "Dehydrofrozen Apples," Food Technology, (4) 426, 1954.

¹⁶W.J. Copley, "The Outlook for Freezing and Dehydrofreezing in Food Preservation," paper presented at the meeting of American Society Refrigeration Engineers, Chicago, November 14, 1957.

¹⁷Mildred M. Boggs, and W.F. Talburt, "Comparison of Frozen and Dehydrofrozen Peas with Fresh and Stored Pod Peas," Food Technology, (6), 1952, p. 433.

Table 4.1. Estimate Cost of Containers, Storage, and Transportation for Green Peas Processed by Three Methods and Shipped from Pacific Northwest to Midwest. Basis is 100 Pounds of Raw Materials.

	Containers	Storage	Transportation	Total
Dehydrofrozen	\$.65	\$.65	\$1.05	\$2.35
Frozen	1.30	1.30	2.10	4.70
Canned	2.45	.60	2.55	5.60

Dehydrofreezing has been applied successfully to some fruits and vegetables and these dehydrofrozen products have demonstrated consumer acceptance. Talburt, *et al.*, reported that dehydrofreezing proved to be satisfactory when applied to many Western apple varieties.¹⁸

According to Talburt and Legault consumer preference test showed that dehydrofrozen peas (partially dried to reduce weight and volume by about 50 percent) were equal in all respects to frozen peas.¹⁹

Dehydrofrozen apple slices were highly accepted by bakeries and institutions currently using frozen apple slices according to Craig.²⁰

¹⁸Talburt, *et al.*, op.cit.

¹⁹W.F. Talburt, and R.R. Legault, "Dehydrofrozen Peas," Food Technology, (4), 1950, p. 263.

²⁰W. Smith Craig, and M.W. Stuckman, "Market Potential for Dehydrofrozen and Dehydrocanned Apple Slices," Agricultural Economics Volume 601, September, 1960, Michigan State University, East Lansing.

In a consumer preference panel test conducted by Greig and associates, pies made from dehydrofrozen apple slices were significantly preferred over apple slices from three other processes.²¹

EXPLOSIVE-PUFFING PROCESS

Explosive-puffing is a new process developed at the Department of Agriculture's Eastern Utilization Research and Development Division near Philadelphia.²² It produces relatively larger dehydrated fruit and vegetable pieces that can be dehydrated and rehydrated more rapidly than those from conventional dehydration processes. Eisenhardt describes this new process: "The vegetable or fruit pieces are partially dehydrated in a conventional manner and heated in a closed vessel having a quick opening lid. When the water contained within the pieces is heated above its atmospheric boiling point and pressure has thereby developed within the chamber, the pieces are instantly discharged. The flashing of water vapor from within each piece creates a porous structure that permits much faster dehydration and much more rapid rehydration of the dried product."²³

²¹W. Smith Greig, M.E. Grant and H. Larzelere, "The Effect of Methods of Freezing Apple Slices on Consumer Preference for Pies," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Vol. 42, No. 4, May 1960, pp. 929-935.

²²J. Cording, Jr., and R.K. Eskew, U.S. Patent 3,039, 813 (June 1962).

²³Eisenhardt, H.H., J. Cording, Jr., R.K. Eskew and J.F. Sullivan, (May 1962), "Quick-cooking Dehydrated Vegetable Pieces," Food Technol. Vol. XVI, No. 5, pp. 143-146.

Explosion puffing has been successfully applied on a pilot plant scale to white potatoes, sweet potatoes,²⁴ carrots and beets,²⁵ as well as to apple slices and blueberries.²⁶ The quick-cooking dehydrated products, depending on the commodity, can be rehydrated for use in from 2-5 minutes in contrast to 30 minutes to an hour frequently required for vegetable pieces of the same size.

Quick-cooking dehydrated fruits and vegetables have certain advantages over canned and frozen products.²⁷ a) Quick-cooking dehydrated products have less weight and bulk and therefore storage, shipping, packaging costs are also reduced, b) and larger fruits and vegetables pieces are rehydrated, easier, better, and faster.

The explosive-puffing process yields products which might be adaptable for use in many types of blueberry products,

²⁴J. F. Sullivan, J. Cording, Jr., and R.K. Eskew, (November, 1963), "Quick-cooking Dehydrated Sweet Potatoes," Food Eng., Vol. XXXV, No. 11, pp. 59-60.

²⁵J. Cording, Jr., R.K. Eskew, J.F. Sullivan, and N.H. Eisenhardt, (June 1963), "Quick-cooking Dehydrated Vegetables, Carrots and Beets," Food Eng., Vol. XXXV, No. 6, pp. 52-55.

²⁶N.H. Eisenhardt, R.K. Eskew, and J. Cording, Jr., "Explosion-puffing Process Applies to Apples and Blueberries," (Manuscript submitted Food Eng.).

²⁷The process is referred to as "explosive-puffing process" while the processed product as "quick-cooking."

i.e., for use in pies, muffins, muffin and pancake mixes, tarts,

There are other processing technologies which have recently been developed and have product possibilities.²⁸ Vacuum concentration with essence recovery has been used on fruit juices. Fruit juices are concentrated to a 6 or 7 to 1 concentration and the essence added back and later frozen or canned. Heid,²⁹ et al., and Keller,³⁰ et al., have written on fruit juice concentrates.

Vacuum drying which may be applied on fruits and vegetables involves the removal of water at relatively low temperatures under vacuum. Bonnell,³¹ et al., have studied vacuum drying on grapefruits and oranges, Notter,³² et al., on pineapple and Kaufman,³³ et al., on tomatoes.

²⁸This part of the research paper was largely adopted from a speech, "Product Development, Market Development and Competition," by Dr. W. Smith Craig of Michigan State University at the 49th Annual Convention of the Pennsylvania Cannery Association, York, Pennsylvania, November 19, 1961.

²⁹J.L. Heid, and E.J. Kelley, "The Concentration and Dehydration of Citrus Juices," Cannery 116 (5) 9-13, 21-22, 24, 26, 27, 30, 32, (6) 13-15, 1951.

³⁰G.J. Keller, R.G. Rice, and E.J. McCulloch, "A Low Temperature Concentrated Tomato Juice," Northern Canner and Packer, August, 1952.

³¹J.M. Bonnell, S.I. Stroschum and W.R. Dorsey, "Commercial Production of Orange and Grapefruit Crystals," Florida State Horticulture Society, 114-116, 1955.

³²G.K. Notter, D.H. Taylor and J.E. Bracke, "Pineapple Juice Powder," Food Technology, (9), 363, 1953.

³³V.F. Kaufman, F.F. Wong, D.H. Taylor and W.F. Talburt, "Problems in the Production of Tomato Juice Powder by Vacuum," Food Technology, (9), 120, 1953.

Flake drying involves drying of slurried or pureed products on large heated drums or rollers. Cording,³⁴ et al., and Eskew,³⁵ et al., have written on the flake process.

In the foam mat drying process concentrated juices or purees are whipped into a foam after the addition of chemical foaming agents. The foam is then spread in a thin layer on a perforated, continuous belt and hot air is forced through the foam. The foam dries up rapidly and then it is crushed. Ginnette,³⁶ et al., has written on the process of dehydrating foams and Bissett,³⁷ et al., on foam mat dried orange juice.

Radiation preservation of foods involves sterilizing foods with ionizing radiations. This is recently developed technology and so far only irradiated bacon has been approved

³⁴J. Cording, Jr., R.K. Eskew, F.H. Dranya, J.F. Sullivan and C.F. Woodward, "Potato Flakes-V-Potato Flakes of Increased Density", USDA, ARS, ARS 73-30, 1960.

³⁵R.K. Eskew, J.Cording, Jr., M.J. Willard, Jr., and J.F. Sullivan, "Advances in the Dehydration of Mashed Potatoes by Flake Process," Food Technology, 9, 1957, p. 236.

³⁶L.F. Ginnette, R.A. Graham and A.I. Morgan, "Process of Dehydrating Foams," Patent No. 2,981,629.

³⁷O.W. Bissett, J.H. Tatum, C.J. Wagner, Jr., H.K. Velamuri, R.F. Graham and A.I. Morgan, Jr., "Foam-Mat Dried Orange Juice," Food Technology, 17 (No. 2), 1963, pp. 92-93.

for use by Food and Drug Administration. ³⁸ *sin*,³⁸ has reported on the program on radiation preservation of food, Goldblith,³⁹ on research and development of radiation preservation of foods,

Another method of drying is the application of sonic irradiation to moist materials. The sonic vibrations which enhance drying rather than utilizing the air vibrations to effect the process is the underlying principle. Boucher⁴⁰ and Greguess⁴¹ worked on textiles and other porous materials and found that sonics could be used to boost heatless drying.

Several new food processing technologies were developed after dehydration, canning and freezing. These were dehydro-freezing, explosive-puffing, freeze-drying, vacuum concentration, vacuum drying, flake drying, foam matt drying, commercial irradiation and sonic drying. Most of these new techniques are

³⁸*sin*, Ralph, "The United States Program of Radiation-Preservation of Foods," Radiation Research, Proceedings of an International Conference Commemorating the operational availability of the U.S. Army Radiation Laboratory, Natick, Massachusetts, January 14-16, 1963, pp. 19-26.

³⁹S.A. Goldblith, "Radiation Preservation Foods—Two Decades of Research and Development," Radiation Research, Proceedings of an International Conference commemorating the operational availability of the U.S. Army Radiation Laboratory, Natick, Massachusetts, January 14-16, 1963, pp. 155-167.

⁴⁰A.M.G. Boucher, "Ultrasonic Boosts Heatless Drying," Chemical Engineering, September 21, 1959, pp. 151-154.

⁴¹P. Greguess, "Drying by Airborne Ultrasonic," Ultrasonic News, 5:3:7-11, Fall, 1961.

basically dehydration or concentration methods and thus considerable reduction in weight is realized when applied in food products. The development of these new processes of food preservation could be attributed to three general reasons; for preservation, for cost reduction and convenience.

Of these, new processing technologies, dehydrofreezing and explosive-puffing were considered to be best adopted to yield products which might be adopted for use in many types of blueberry products, such as pies, muffins, jam, jelly, and others.

Chapter V

PRE-MARKET TESTS

A. INTRODUCTION

As some pre-market tests were used to determine partially the feasibility of using some new processing technologies for blueberries, a general review of market test methods and their applicability to new development will be discussed.

The use of pre-market testing is an important phase of the food product development program. This is evidenced by the ever-increasing new products brought out to the market, the rising cost facing the suppliers and the distributors and the high mortality rate of products introduced in the market. Seventy percent of the individual food items sold by a chain store in 1959 were not in existence 10 years ago.¹ About one third of 99 products of a large food manufacturer have been introduced in the last 5 years and over two thirds of its fresh line is new since World War II.² Items carried in the grocery departments have grown from 2,200 in 1950 to 4,900 in 1958.³

¹The Big Challenge to Food Marketing, Eighth Biennial Grocery Study, New York, This Week Magazine, 1959, p. 9.

²Campbell Soup Company Annual Report, Fiscal Year, 1957, p. 7.

³"Supermarket Industry Speaks, Chicago Supermarket Institute, 1959, p. 19.

Product development and promotion are costly. The cost of developing and marketing a new product nationally is estimated to be around one million dollars.⁴ To indicate the high cost of developing sales for a new product, in 1960, five distributors of processed potatoes spent \$8,703,000 to promote dehydrated potato products.⁵

Not all products introduced in the market become successful or profitable. About 60 to 90 percent of the products introduced in the market turned out to be failures.⁶

There are five general tests in conducting a pre-market evaluation of new food products and these are: (1) laboratory panel test, (2) the mass consumer panel test, (3) the retail sales test, (4) the demonstration-interview, (5) institutional sales test.

8. Laboratory Panel Test

The laboratory panel may be composed of expert or lay panel members. The expert members are trained in testing procedures. These members have had extensive experience in sensory testing, and are able to detect specific flavors in the presence of other flavors. On the other hand, the lay

⁴The Big Challenge in Food Marketing, *QMA File*, p. 29.

⁵*QMA File*, p. 9.

⁶The Big Challenge in Food Marketing, *QMA File*, p. 9.

members have had less experience in testing and evaluating samples. These lay members are less sensitive since they lack experience, ability and training. This type of panel is mainly used to determine the typical consumer preference.

The laboratory panels are used for quality control tests, developing of new or improved products, and possibility of food experimental work. A great number of food processors maintain laboratory panels to test consumer preference for new products. The panel members are asked to test various samples of new food products under controlled environment. They are also asked to give their order of preference among the samples of new products in regards to taste, appearance, odor and other product characteristics.

Numerous researches on consumer preference have been conducted with the use of laboratory panels. Greig and Larzelere have used Michigan State University consumer preference panel in Detroit to test consumer preference of new apple and potato products,⁷ and Larzelere and Gibbs to determine consumer opinions of quality in pork chops.⁸ Lockhart and Gaines used large laboratory panels to test consumer preferences for

⁷W. Smith Greig, and H. Larzelere, "Consumer Taste Preferences Among Dehydrated Mashed Potatoes Products," Nat. Potato Council News, Vol. V, No. 2, 1957, pp. 4-6.

⁸H.E. Larzelere, and R.D. Gibbs, 1956, "Consumers' Opinions of Quality in Pork Chops," Michigan Agr. Expt. Station Quarterly Bulletin 39, pp. 327-333.

canned and frozen orange juices,⁹ while Darymple used a similar panel to test consumer preference for various grades of applesauces.¹⁰ The USDA used a small panel to distinguish between grades of peas.¹¹ Kiehl and Rhodes used the triangle method to test discrimination between samples of steaks with comparisons being made within grades and between grades.¹²

The use of laboratory panel to test consumer preference among newly developed products offer some advantages. Tests are carried out under controlled conditions. This insures uniformity of test conditions and reduces the number of variables entering into the tests. The results reflect differences between the characteristics of various samples.

It is believed that lay members would be more attentive and critical than the average person, thus the results would reflect a more accurate preference.

The test is usually held in one location. Through scheduling, the most efficient and convenient use can be made

⁹E. E. Lockhart, and J. M. Gaines, "Acceptance of Fresh Frozen and Canned Orange Juices," Food Research, Vol. 14 (1949) pp. 429-433.

¹⁰D. J. Darymple, A Survey of Applesauce Preferences, (Cornell University Merchandising Experiment Paper, No. 7, Ithaca: Cornell University Press, 1959).

¹¹"Consumer Preference for Frozen Peas in Relation to standards for Grades," Marketing Research Report No. 200 (Washington, USDA, MAS, 1953), p. 8.

¹²E. A. Kiehl, V. James Rhodes, "New Technique in Consumer Preference Research," Journal of Farm Economics, Vol. 33, 1935, pp. 1333-1343.

of both the panel members' and test personnel's times. This type of panel test would permit testing of a great variety of newly developed products.

Considerable reduction in expenses is realized from the use of the laboratory panel test because of the limited number of members that compose the panel and because a large number of alternative forms of formulas can be tested without a large investment being made in product testing.

The results of these tests should not be taken as final, but as an absolute and positive indication of consumer preference for products. The results should be used as a guide in product development, a guide that will provide preliminary indication of the product preference potential. New products that are tested could be improved through comments of panel members. Samples or products which show poor results can be culled before a huge sum of money is spent on further development and production.

C. Mass Consumer Panel

After a product has passed the laboratory panel tests, the next logical step in pre-market testing a newly developed product, is to go through a mass consumer test. This next step involves testing the product for consumer preference by larger groups of consumers. The product under test is not conducted in a laboratory but rather these products are used at home. The mass consumer panels are used to determine the

advantages and disadvantages of the newly developed product, and to compare the product under test with the substitutes and competing products selling in the market.

The panel is made up of members which accurately reflect the characteristic of the market population in which the product is going to be sold. The composition of the panel is selected in such a way that it gives a proportional sampling by family sizes, by economic groups, by city sizes, and by geographical areas.¹³

In order to meet the above requirements, it is necessary that a preliminary interview be conducted to screen out those individuals who do not possess the desired characteristics. The selection of members of a mass consumer panel of Kroger Food Foundation was based on: (1) "representative geographical distribution throughout the territory served by the company. Each county thus has its quota of membership in proportion to the number of retail outlets operating in that area. (2) High, medium and low income brackets represented in the proportion indicated by the latest statistics, and (3) distribution of ages within the group, corresponding to the latest census figures."¹⁴

¹³John H. Nair, "Mass Testing Panels," Food Technology, Vol. 9, 1949, p. 134.

¹⁴G. Garnatz, "But What Do The Consumers Say?," Food Industries, Vol. 22, 1950, p. 1333.

A mass consumer panel test has been used to evaluate a 6 to 1 apple juice concentrate,¹⁵ where newly developed products were tested by both laboratory and mass consumer panels for consumer preference, the tests indicated essentially the same results.¹⁶ Even though the two types of test yielded the same results, the laboratory panel tests are conducted under controlled conditions and therefore do not allow the collection of consumer reaction under conditions in which the product is normally used.

Because of the larger number of panel members that make up the panel and because of the feasibility of developing a more representative sample, the mass consumer taste panels provide the researcher a more accurate indication of consumer preference than laboratory panel. Additional comments asked for from respondents serve a valuable aid in the evaluation and development of new products. The mass consumer panel provides consumer potential characteristics which prove useful to more effective promotional efforts.

The mass consumer panels tests are subject to sampling and procedure errors as well as biases. This type of test is more costly, more time consuming, and requires more personnel than laboratory panels.

¹⁵J. Scott Hunter, Consumer Preference for 6 to 1 Apple Juice Concentrate, Marketing Research Report, No. 343, Washington, USDA, AMS, 1959.

¹⁶P.G. Miller, H.H. Nair, and A.J. Harriman, "A Household and a Laboratory Type of Panel for Testing Consumer Preference," Food Technology, IX, 1955, pp. 445-449.

It is important to reiterate that the two tests, the laboratory panel and the mass consumer panel tests are used to evaluate consumer preferences among newly developed products and in these tests, factors which will affect reactions of the consumers of products when placed on the market are not taken into consideration. Brand names, advertising and promoting, pricing, package size and design, alternative uses of the product, variations in recipes and preparation methods, differences in the quality of products used in the tests, and that in the retail stores are factors not considered in these two tests. All these are the factors which may alter the established results of consumer preference tests when the new products are placed on the market. Even if a new product shows high consumer preference, the key to success is consumer acceptance or willingness to buy the product under specified market conditions. Thus it is necessary to conduct retail sales tests which will indicate consumer acceptance under normal market conditions.

D. Product Acceptance Tests

Product acceptance test has two parts, namely, the consumer acceptance test and the institutional acceptance test. The product acceptance test in the institutional market is designed to ascertain that the buyers, dieticians or chefs of institutions will buy and serve the product to their customers when the new product is offered in the market. A product may be bought by consumers but not by

institutions. This may be true when the product is used in small quantities or when the product is not used very often, when products are difficult to prepare, costly, and the storage life is short. On the other hand a product may be highly acceptable to consumers, but may not gain a very wide institutional acceptance because certain types of processed food products may be better suited to use by homemakers than by institutions.

E. Retail Sales Tests

As soon as the new products have passed the laboratory and mass consumer panel tests which will indicate consumer preference, the products undergo a consumer acceptance test called retail sales test. Even though a new product has passed the consumer preference tests, normally it is still essential to conduct a retail sales test to determine the saleability of the new product and to obtain a clear picture of the product's potential before it is marketed in commercial scale. Preferences do not necessarily indicate acceptance or saleability.

Retail sales testing may be described as follows:

"When we choose a test city for the final evaluation, we make every effort to have all or nearly all of the retail food stores carry the new product. A pre-introduction and pre-promotional audit is made in the sample stores to provide a bench mark of sales of competing products, and weekly audits of the new and competing products running for a period of 3 to 5 months are carried out. During the initial period of 4 to 6 weeks, a promotional campaign representing all types of media, including in store demonstrations in a few of the stores, is conducted.....Store audits are continued

"after the promotion period. A follow up household consumer survey usually is made 8 to 10 weeks after the end of the promotional campaign."¹⁷

In some cases the follow up interview is omitted in many retail tests because of the additional expenses, availability of trained personnel, the objective of the test, time limitations, and the degree of cooperation received. It is evident that four basic elements are needed to carry out a retail sales test; the stores, records, cooperation, and financial resources.

The test period should be long enough for the novelty of the product to wear off and for repeat sales to be made. There are various opinions on the length of the test periods. Scott suggests that the test period should be at least one year in order to include seasonal changes.¹⁸

The retail sales test may be accompanied by intensive advertising and promotion programs, which are admissible to have in proportion with what could be carried out on a market wide basis.

Follow up consumer interview to collect information on the acceptance of a new product may be conducted several weeks after the product has been introduced on the test market.

¹⁷T. Meyers, "Predicting Market Acceptance," Journal of Farm Economics, Vol. 37, 1955, p. 8.

¹⁸P.S. Scott, Jr., "Seasonability of Purchases of Frozen Orange Juice Concentrate, Frozen Lemonade Base, and Frozen Passion Fruit Juice," Hawaii Farm Science, Vol. 7, No. 3, January, 1959, p. 4.

The interview will provide information concerning the experiences, likes and dislikes of consumers who used the product, precise information on the purchasing and repeat purchasing, information on consumer characteristics which will be valuable in planning advertising and promotion and information that will make possible the evaluation of advertising and special promotions carried on during the retail sales test.

The U.S. Department of Agriculture (Agricultural Marketing Service) private research organizations, consumer product manufacturer and State Agricultural Experiment Stations have developed and used retail sales tests. Applebaum and Spears described the methodology of retail sales test,¹⁹ Greig and associates used retail sales tests to determine retail sales and elasticity of demand for dehydrated mashed potato products,²⁰ while Dworkin and Jacobs,²¹ used this same test to determine consumer acceptance of dehydrated mashed

¹⁹W. Applebaum, and E. Spears, "Controlled Experimentation in Marketing Research," The Journal of Marketing, XIV, 1950, pp. 505-517.

²⁰W. E. Greig, F. O. Strand and H. E. Larselars, Relative Retail Sales and Elasticity of Demand for Dehydrated Mashed Potato Product, Michigan State University, Department of Agricultural Economics, mimeo 732, E. Lansing; Department of Agricultural Economics, 1952.

²¹P. S. Dworkin, and M. Jacobs, Potato Flakes: A New Form of Dehydrated Mashed Potatoes: Market Position and Consumer Acceptance in Pinchinton Heights and Johnson City, N.Y., U.S. Department of Agriculture Marketing Research Report No. 186, Washington: U.S. Government Printing Office, 1957.

potatoes. The acceptance of frozen stuffed peppers was tested by Braun²² while that of frozen passion fruit juice was tested by Scott.²³ Food manufacturers may have an excellent use for retail sales tests in making vital decisions to market new consumer products.

F. Demonstration-Interview Technique

Demonstration-interview technique is often used in predicting product acceptance by both the institutional and retail markets. In predicting product acceptance by the institutional market, the use of newly developed products is demonstrated to buyers for institutions, while in predicting product acceptance by the retail market, the use of new products is demonstrated to consumers. In both cases, however, the sale of new products does not take place.

The institutional demonstration-interview technique consists of demonstrating the preparation of a new food product to buyers for institutional feeding establishments and then recording the reaction of buyers to the product. Interviews after demonstrations will reveal the reactions of buyers and are the sources of information for predicting product acceptance.

²²E. Braun, Frozen Stuffed Peppers: A New Frozen Food?, South Carolina Expt. Sta. Report No. 127, Clemson: Department of Agricultural Economics, 1957.

²³F. Scott, Frozen Passion Fruit Juice. An Appraisal of the Mainland Market, Hawaii Agricultural Expt. Sta. Report No. 25, Honolulu: Department of Agricultural Economics, 1955.

The demonstration-interview technique has been used by Greig to determine institutional acceptance of dehydrated potato flakes²⁴ and dehydrofrozen apple slices,²⁵ and by McGrath and Sills to test institutional acceptance of dehydrofrozen peas.²⁶ McCreary reported that the demonstration-interview technique used by Greig provided a fairly reliable prediction of total sales of dehydrated potato products.²⁷

G. Institutional Sales Tests

Newly developed products are not only tested for consumer acceptance, but also for institutional acceptance. The acceptance of new products at the institutional level will be determined by dietitians, chefs, managers and food supervisors.

²⁴ W.S. Greig, The Restaurant, Hotel, and Institutional Market for Dehydrated Peeled Potatoes, Michigan State University Preliminary Report (East Lansing: Department of Agricultural Economics, 1957).

²⁵ W.S. Greig, Market Potential for Dehydrofrozen and Rehydrated Apple Slices, Department of Agricultural Economics Memo No. 691 (East Lansing: Michigan State University, 1960).

²⁶ E.J. McGrath and M.S. Sills, Restaurant Acceptance of Dehydrofrozen Peas, U.S. Department of Agriculture Marketing Research Report No. 199 (Washington: U.S. Government Printing Office, 1937).

²⁷ E.K. McCreary, The Use of Demonstration Interview Technique in Estimating the Institutional Acceptance of Dehydrated Peeled Potatoes, (unpublished master's dissertation, Department of Agricultural Economics, Michigan State University, 1962), p. 45.

of institutions such as churches, schools, in-plant feeding establishments, restaurants, and other public eating places. In this test, the products are actually sold to institutions and are used in these feeding establishments. Marine describes the institutional sales test technique he used to determine institutional acceptance of frozen diced onions:

"The method consists of the six following steps: (1) Distribution of product samples to selected institutions by distributor salesman, (2) recording of first reactions to the product, (3) attempts to sell the product to institutions by distributor salesman, (4) keeping weekly records of initial and repeat sales of the product to individual establishments for a period of 12 weeks, (5) keeping weekly records of total sales in the test market for a period of 12 months, (6) maintenance of a supply of product in a central warehouse to be drawn on as needed to fill orders, and (7) survey a sample of institutions in the test market after the sales test to gather data on utilization and purchases of the tested product and competing products and to determine market penetration of the tested product....."²⁸

At present there is a lack of published methodology for conducting institutional sales tests.

H. Summary of Market Tests

Because the introduction of new products is risky and costly, pre-market testing becomes a necessity before these products are placed in the market on a commercial scale. Product testing also gives accurate indications of consumer preference and acceptance. Valuable information may be

²⁸Marine, *op. cit.*, p. 40.

obtained which may guide product improvement and planning of future promotion and production of the product.

The general procedure for pre-market testing is:

- (a) laboratory panel test--This is used to aid in the initial phase of product development and to gather information on consumer preference.
- (b) Mass consumer panel test--The consumers use the product at home and are later interviewed to obtain their reactions and suggestions on the product. This test aids the researcher in product development and improvement and also gives a more definite indication of consumer preferences. Additional information obtained from this test may indicate the potential product characteristics which are of great value in planning promotions and production.
- (c) retail sales tests--This test is designed to indicate the saleability of the product to consumers, or the consumer product acceptance under actual market conditions. This test will furnish the researcher information on the retail market potential of new product, a market potential which would be vital in deciding whether to market the product, or disregard it.
- (d) institutional sales tests--This test is designed to indicate the saleability of products to buyers

for institutional establishments. It also furnishes the researcher information in the institutional market potential of new products. Both the retail and institutional sales test involve the selling of products.

- (a) **demonstration interview technique**—This test is designed to indicate the acceptance of products both on the consumer and institutional levels. This test provides an estimate of the product potential on both levels. Demonstration of the preparation of new products and interview comprise this test, but the products tested are not sold.

As mentioned earlier in this research paper, there are many factors which favor processing of blueberries and in developing blueberry products. However, the high cost of introducing a new blueberry product, pre-market testing is deemed necessary before blueberry products are placed on the market on commercial scale. Thus one of the purposes of the laboratory test is to find out consumer preference panel acceptability of new blueberry product forms.

In the test of new blueberry products reported in this thesis, the Consumer Preference Panel (a laboratory type mass consumer panel) of Michigan State University was used. The results are not final but are helpful in further product improvement. The consumer preference test employed in this research paper is the initial step in pre-market testing.

The use of Michigan State University Consumer Preference laboratory-type mass panel was most appropriate in conducting the preference tests as the results of these tests were used as initial guides in developing blueberry products and as they provided preliminary indications of consumer preference potentials for these blueberry products. The use of the laboratory panel limited the number of variables that affected the tests and at the same time permitted the testing of a great variety of new products. Substantial savings was another consideration taken in the use of the laboratory panel.

Chapter VI

THE CONSUMER PREFERENCE TESTS

A. Consumer Panel Test Objective

The tests reported here were designed to determine the feasibility of using products from two new processing methods for blueberries by determining consumer preference panel acceptability of these two new product forms. The decision to use the consumer preference panel was prompted by its appropriateness to test the products at their early stage of development and also the economy in using an already established panel. The tests reported are the first tests for dehydrofrozen and quick-cooking blueberries and served primarily as screening tests. The results are not final but may be very useful as guides in further product development and market testing.

B. Experimental Materials

In these tests dehydrofrozen blueberries were used in pie while quick-cooking dehydrated blueberries were used in both pie and muffins. These products were produced under laboratory conditions. The quick-cooking dehydrated blueberries from the explosive-puffing process were tested against canned blueberries in blueberry muffin forms and dehydrofrozen blueberries were tested against normally frozen blueberries in pie forms. A screening test was also conducted of blueberry

pies made from quick-cooking, frozen, and canned blueberries.

Dehydrofrozen blueberry samples were prepared by Dr. Clifford Bedford, Department of Food Science, Michigan State University.

The pre-treated dehydrofrozen blueberry samples were reconstituted with water. Sugar, cornstarch, salt, lemon juice and butter were added to the reconstituted blueberries to form the blueberry pie fillings. A commercial pie filling recipe was used. Approximately 20 ounces of pie fillings were placed in 9-inch aluminum pans and covered with pie crust. The pies were wrapped in aluminum foil, frozen, stored, and baked 12 hours before the consumer preference panel tests were to be conducted.

The blueberries which were used in the preparation of the pie fillings were processed and treated as follows:

- (a) for control, the blueberries were frozen in a normal fashion,
- (b) for dehydrofrozen control, the blueberries were dried at 160°F to 50 percent of their original weight and volume and then were frozen at -5°F ,
- (c) for dehydrofrozen nicked,¹ the blueberries were rolled over a plate, under slight pressure with razor sharp triangular blades protruding

¹The "nicking" and "pricking" treatments were designed to alleviate "skin toughness" problems sometimes associated with frozen blueberries.

sufficiently far to cut through the skin. After this treatment the berries were dried to 50 percent of their original weight and volume and then frozen at -5°F .

- (d) For the dehydrofrozen pricked the blueberries were rolled over a needle board so that pin size holes were made in the skin. After this treatment the berries were dried to 50 percent of their original weight and volume and then frozen at -5°F .

In the preparation of muffins quick-cooking dehydrated blueberries, were used as muffin mixes. Cultivated blueberries were processed by the explosive-puffing process by the Eastern Regional Research and Development Division, United States Department of Agriculture at Philadelphia, Pennsylvania. The quick-cooking dehydrated blueberries packaged in sealed cans. Muffins from both quick-cooking dehydrated and canned blueberries were prepared by the Home Economics Department, Michigan State University. About 27 grams of dehydrated blueberries were added to one cup of boiling water and were allowed to simmer from 1 to 2 minutes. The reconstituted blueberries were then rinsed, dried and used in recipe with prepared muffin mix in lieu of canned blueberries. The muffins were baked, sealed in aluminum foil and frozen. The frozen muffins were subsequently thawed before being served to the consumer preference panel.

Consumers' preference ranking and triangle tests were conducted through the Michigan State University Consumer

Preference Panel. One of the main functions of this Consumer Panel is to pre-test new products and ideas and to obtain answers which will guide producers, processors, wholesalers and retailers. The Consumer Panel, a marketing project of Michigan State University, with the cooperation of Wayne State University, is headed by Dr. Henry Larselore of the Department of Agricultural Economics of Michigan State University, and Professor Mary Jane Hostick of the Home Economics Department of Wayne State University. This panel usually meets 4 to 5 times a year at Wayne State University in Detroit, Michigan.

The panel was originally developed in the following manner, in 1936 a sample census of about 6,500 names was selected from the latest Detroit telephone directory, by a stratified systematic sample. These persons selected from the telephone directory were sent mail questionnaires that asked for the following information: age group, educational attainment, employment outside home, estimates of income after taxes (federal) and other questions related to consumer purchasing. These control factors were chosen because of their importance as a factor related to the consumption of food. About 3 percent of the questionnaires sent to 6,500 Detroit residents were returned for non-delivery and about 20 percent of the remainder were filled out and returned.

From those who agreed to participate, a panel of from 120-130 consumers are selected for each panel test. This

panel was representative of consumers in the sample area; these consumers were in the middle income group (\$4,000 to \$10,000 yearly income), had received 12 to 13 years of education and were in the 31 to 45 age group.

Each year, approximately 20 to 40 basic sample panel members with the same characteristics as those of the active panel are recruited to take the place of those who drop from the active panel.

Families who attended the consumer panel tests were paid \$4.00.

Though selected active panel members were mostly women since purchases are made mostly by women, husbands were also permitted to sample the products on test.

Children and guests were allowed to sample the products, but their score cards were disregarded in the analysis of the test.

The panel members were reminded of the forthcoming consumer panel test by means of a post card which indicated the day and the specific time panel members were expected to report at Wayne State University. The experiments were conducted as a part of the Michigan State University Consumer Preference Panel on November 14, 1962, February 19, and April 4, 1963. The panel met from 2 o'clock in the afternoon until 9 o'clock in the evening. Before the consumers were asked to sample the products, they were briefed on the general purpose of the project and were given instructions concerning the different series of items. The consumers were not told the

purpose of any specific tests. The consumers were asked to perform the test independently of one another. After the briefing the consumers were led to the laboratory room in groups of 10 to 20 consumers at a time. As soon as each consumer completed his product lists, his cards were checked to make sure that each question was answered properly.

C. Experimental Procedure

In this study, two types of tests were conducted, the consumer preference ranking test and the triangle test.

Ranking Test

In the consumer preference ranking test the consumers were merely asked to sample the pie and rank according to their preference from, 1, highest, to 4, lowest. The consumers were not asked the reasons for their preference but were encouraged to write voluntary comments. It was not explained to panel members whether the test was for crust, color, texture, consistency, appearance, different recipes, processing techniques, or varieties. The paper plates that contained the samples were coded by symbols such as, %, \$, *, and () to prevent the possible influence of ranking association by use of letters or numbers. These symbols were alternated randomly to avoid a certain pie sample from being continually in the same position.

Though the tests were considered taste tests, each panel member was served 1/8 of a 9-inch pie from each sample.

Each sample was large enough so that appearance may have been considered in the taste ranking.

In the analysis of the preference ranking test, each individual consumer was asked to rank the sample in the order of preference from one to four. A weighted rank score of each sample was determined obtaining the product of different percentages of total rankings and the various assigned weights for the different levels of choices such that the percentage of total first choice was multiplied by 4 points, the second choice by 3 points, the third choice by 2 points, the last choice by 1 point. (See appendix for computation). The sample that obtained the highest score in each series was considered preferred by the largest number of panel members.

The degree of concordance was used to determine significance in the overall test and if a significant difference was obtained the chi-square (χ^2) test was used to determine differences between individual samples.

Triangle Test

In the triangle tests, the panel members were given three samples, two of which were identical and the other "different" sample. In addition, they were asked which sample they preferred, the "identical" or the "different" sample. The odds for a correct answer by chance are 1 in 3 for distinguishment and 1 in 6 for preference. Tests of significance were conducted both for distinguishment and for preference.

D. Limitations of the Study

This study is subject to certain limitations and these limitations arise from the preparations of the samples, ranking test method, triangle test method, and laboratory panel tests.

1. In the first preference test for pies, the four types of blueberry pie fillings did not have quite the same consistency. Pies made from untreated dehydrofrozen pie fillings appeared to be thicker than the rest of the pie fillings because water was rapidly absorbed by the dehydrofrozen berries. This resulted in addition of more water to the untreated pie fillings.
2. The pie fillings used in the first preference ranking test were prepared every Friday for four consecutive weeks. Each Friday ten pies of each type were frozen. This meant that the pies were not prepared all at one time; some were frozen as long as four weeks before cooking and some were frozen a week before cooking.
3. In the ranking method there is a possibility of the misinterpretation of the positive results even if we assume that other sources of bias were removed through experimental design and statistical techniques. According to Platt² there are four possible sources of bias from the

²Washington Platt, "How Will Consumers Rate Your Products?", Food Industries, Vol. 9 (1937), p. 9.

interpretation of positive responses. These are: (1) when the respondent is unable to distinguish between the samples his vote may be a pure guess, (2) when a respondent has only a slight preference, he may select either product and be satisfied, (3) when a respondent has a strong preference for the product, he may buy only the preferred product, and (4) the respondent may think both products are good or bad but prefers one over the other. However, some of these are partially corrected in the use of the panel.

4. Since three samples were being used in the triangle test, more time was required to complete the test than the paired test.

5. The use of laboratory panel to test products presents the following problems:

- (a) It is fitting to assume that the lay panel members have more interest in testing products than the non-panel members (normal consumers). This may tend to bias the panel results even though the interest may be stimulated by the monetary rewards.
- (b) The laboratory panel tests were conducted under unnatural or abnormal conditions because the samples tested were in smaller proportions than those when products were to be eaten at home. Samples were served between meals; the samples were tested while consumers were standing, while under normal circumstances they would be sitting down.

- (c) The use of the same panel members over a long period of time has made the panel members more proficient and a professional attitude may have developed which reduces representativeness.
- (d) Experimental control of some variables were unavoidable such as keeping preparation methods uniform, securing uniform samples, and also maintaining sample quality.
- (e) The results cannot be taken as final since these were obtained from relatively small number of respondents' opinion.

E. Results

Test 1 - Dehydrofrozen Blueberry Filling

Consumer preference ranking tests were conducted among the samples of blueberry pies made from normally frozen, dehydrofrozen untreated, dehydrofrozen nicked, and dehydrofrozen pricked blueberry pie fillings. The consumers ranked each sample of each type of blueberry pie according to preference, 1, highest to 4, lowest.

Of the 146 consumers, 64 percent preferred the pie made of normally frozen blueberries, dehydrofrozen control, 9 percent, dehydrofrozen nicked, 14 percent and dehydrofrozen pricked, 14 percent.

A statistical analysis of results indicated a highly significant agreement among consumers that there was a difference in preference for the pies. Pies made from normally frozen blueberries were significantly preferred over pies

Table 6.1. Consumer Panel Preference Ranking of Pies Made from Normally Frozen, Untreated Dehydrofrozen, and Pretreated Dehydrofrozen Blueberry Pie Fillings, 145 Consumers, Detroit, Michigan, November 14, 1962.

Pies**	First	Second	Third	Fourth	Total
Control (Normally Frozen)	94	25	13	13	145
Dehydrofrozen control	12	53	39	41	145
Dehydrofrozen nicked	20	39	51	35	145
Dehydrofrozen pricked	20	37	40	48	145
	145	154	143	137	

**Significant differences in ranking at the 1 percent level. The odds are 99 to 1 that these differences in ranking were not due to chance alone.

made from dehydrofrozen (control) blueberries, dehydrofrozen nicked and dehydrofrozen pricked blueberries. There were no significant preferences among any other comparisons.

Test II - Dehydrofrozen Blueberry Pies

A blueberry pie triangle test was conducted on February 13, 1963, to confirm that there was no significant difference in the preference between the dehydrofrozen control and dehydrofrozen pricked blueberry pies. With the triangle test method, each panel member was given three samples, two of which were identical and one "different." The consumers were asked to pick out the "different" sample.

Of the 139 consumers testing dehydrofrozen control and dehydrofrozen pricked blueberry pie fillings in the triangle test, 70 consumers or about 50 percent were able to differentiate between two products. This indicated that there were distinguishable differences between pies made from the two pie fillings.

Of the 69 consumers who were able to differentiate pies made from the two sides, 52 percent preferred the pies made from dehydrofrozen pricked pie fillings. This difference in preference was not significant and could have been due to chance.

Table 6.2. Triangle Test of Pies Made from Dehydrofrozen Control and Dehydrofrozen Pricked Blueberry Pie Fillings, 139 Consumers, Detroit, Michigan, Feb. 19, 1960

Total consumers participating	139
Could not differentiate products	69
Correctly differentiated between products	70**
Preference for dehydrofrozen pricked 36 <u>N.S.</u>	
Preference for dehydrofrozen control 32 <u>N.S.</u>	

Total correctly differentiating	63
---------------------------------	----

N.S./ Non-significant at the 1 percent level.

**Consumer discernment of differences significant at 1 percent level.

(Of the 70 consumers who were able to differentiate correctly between the two pies two (2) consumers did not answer the second question.)

The blueberry pie triangle test conducted confirmed that there was no significant difference in the preference between the dehydrofrozen control and dehydrofrozen pricked blueberry pies.

Test III - Quick-Cooking Blueberry Muffins

On November 14, 1962, a triangle test of the muffins made from quick-cooking blueberries and canned blueberries was conducted with the consumer preference panel. In general, the same methods were used as in the previously reported triangle test with the dehydrofrozen pies. Each consumer was served 3 halves of blueberry muffins, two of which were identical and one which was "different." The consumer was asked to identify the different sample and to indicate which was preferred, the "different" or identical samples.

Of the 154 consumers testing quick-cooking blueberry muffins and canned blueberry muffins in the triangle test, 99 consumers or 63 percent were able to differentiate correctly the two products. This indicates that there were distinguishable differences between muffins made by the two methods.

Of the 99 consumers who were able to differentiate muffins made from the two mixes, 59 preferred the muffin made from canned blueberry mix and 40 the quick-cooking mix. This difference in preference was not quite significant and could have been due to chance.

Test IV - Quick-Cooking Blueberry Muffins

The muffin triangle test method of comparing muffins made from quick-cooking and ordinary canned blueberry muffins

Table 6.1. Triangle Test of Muffins Made From Quick-Cooking Dehydrated and Ordinary Canned Blueberries, 156 Consumers, Detroit, Michigan, November 14, 1962.

Total consumers participating	156
could not differentiate products	<u>57</u>
correctly differentiated between products	99**
preference for quick-cooking mix	43
preference for canned blueberry mix	<u>56</u>
Total correctly differentiating	99

**Consumer discernment of differences significant at the 1 percent level. Differences in preference were not significant at the 1 percent level.

was repeated on February 19, 1963. The same methods were employed as those in the previous tests. The results were nearly identical to the first test.

Of the 147 consumers testing quick-cooking dehydrated blueberry muffins and ordinary canned blueberry muffins 70 percent were able to distinguish between the products. This indicated that there were distinguishable differences between muffins made by the two methods.

Of the 101 consumers who were able to differentiate muffins made from the two mixes about 55 percent preferred the muffins made from canned blueberries. This difference in preference was not significant and could have been due to chance.

Table 6.4. Triangle Test of Muffins Made From Quick-Cooking and Ordinary Canned Blueberry Muffins, 147 Consumers, Detroit, Michigan, February 19, 1963.

Total consumers participating	147
could not differentiate products	44
correctly differentiated products	103**
preference for quick-cooking blueberry mix	44 51 ¹⁰³
preference for canned blueberry mix	51 ¹⁰³
	101

**Highly significant differentiation

~~51~~ / Non-significant differences at the 1 percent level.

(Of 103 consumers who were able to differentiate correctly between the two muffin mixes two (2) consumers did not answer the second question.)

If the results of the two triangle tests are combined (this is not completely justifiable statistically) then the canned blueberry muffins are significantly preferred at the 5% level; or the odds are greater than 19 to 1 that the preference for muffins containing canned blueberries was not due to chance alone. (Table 6.5) These two triangle tests were combined in order to determine the effects of a larger number of tasters on the results of the test. The result of combining these two tests suggested that in the future the use of a larger number of panel members may increase the accuracy of the statistical results.

Table 6.5. Combined November and February Triangle Test of Muffins Made From Quick-Cooking Dehydrated and Ordinary Canned Blueberry Muffin Mixes, 303 Consumers, Detroit, Michigan.

total consumer participating	147 + 156	= 303
could not differentiate products	44 + 57	= 101
could correctly differentiate products	103 + 99	= 202**
preference for quick-cooking blueberry	44 + 40	= 84 ^{ns}
preference for canned blueberry mix	57 + 59	= 116 ^g
Total correctly differentiating		200

**Highly significant differentiation at the 1 percent level.

^g/ Significantly different at the 5 percent level.

^{ns}/ Non-significant at the 5 percent level.

(Of 303 consumers who were able to differentiate correctly between the two muffin mixes two (2) consumers did not answer the second question.)

Of the 303 consumers (this was not 303 consumers because a large number were duplicates) testing quick-cooking dehydrated blueberry mix and ordinary canned blueberry muffins mix in two triangle tests, 66.6 percent were able to distinguish between the products. This indicated that there were distinguishable differences between the muffins made from the two mixes. Though the test was considered taste test, there was a possibility that appearance or visual differences among samples affected consumers' preferences.

Of the 200 consumers who were able to differentiate muffins made from the two mixes about 58 percent preferred the muffins made from canned blueberry mix. This difference in preference was barely significant at the 5 percent level.

Test VI - Screening Test of Quick-Cooking Blueberries in Blueberry Pies

On April 4, 1963, a preliminary screening test of quick-cooking blueberries in pie form compared to canned blueberries and frozen blueberries was conducted.

Table 6.6. Consumer Panel Preference Ranking of Pies Made From Normally Frozen, Canned and Quick-Cooking Blueberry Pie Fillings, 131 Consumers, Detroit, Michigan, April 4, 1963.

Type of Pie Filling	Number of Times Ranked			Total Consumer
	First	Second	Third	
Canned	84	41	6	131
Frozen	36	66	29	131
Quick-cooking	11	24	96	131
Total Consumers	131	131	131	

Significant differences in ranking at the 1 percent level. The odds are 99 to 1 that these differences in ranking were not due to chance.

Of 131 consumers sampling, pies made from canned blueberry pie fillings were ranked first 84 times, frozen 36 times and quick-cooking dehydrated 11 times. A statistical analysis of result indicated a highly significant agreement among consumers that there was a difference in preference for pies.

In this test, the pies from canned blueberries were ranked significantly higher than those from frozen and quick-cooking blueberries and the frozen blueberries were ranked significantly higher than pies from quick-cooking blueberries. However, because of the limited supplies of quick-cooking blueberries, only a limited number of trial recipes were developed from the quick-cooking blueberries. The low rating for pies from quick-cooking may have been partially due to preparation methods. Some comments were "too gummy," "too sweet," and "no taste" for pies from quick-cooking blueberries.

Chapter VII

SUMMARY AND CONCLUSION

The rising freight rates, expensive storage cost, relatively high packaging outlay, institution and consumer demand for convenience food products, increasing trend in blueberry production and processing, expanding total consumption and per capita consumption of both fresh and processed blueberries, concentration of blueberry consumption near the area of production, relatively elastic demand for commercially prepared pies, and the fact that the price of blueberry pies is higher than the average price of commercial fruit pies--all these factors were partially responsible for the initiation of research for new processing technologies and the research reported here to determine the feasibility of new product use to reduce cost of processing, storage, packaging and distribution, and, therefore increase sales of blueberry products.

Thus the objectives of this study were: (a) to review the trends in blueberry production, consumption and utilization, and (b) to make a progress report on the feasibility of using products from two new processing methods for blueberries by determining consumer preference panel acceptability of these two new products.

Blueberry production in the United States has been expanding rapidly. While total blueberry production is increasing, the acreage harvested has also been increasing, but

at a slower pace. National yield per acre has exhibited a 167 percent increase from 1939 to 1959. The U.S. blueberry industry is concentrated in Michigan and eastern states such as Maine, New Jersey, North Carolina and in Washington. These states, since 1949, have supplied over 80 percent of the total U.S. blueberries.

The total volume of blueberries processed increased from about 27 million pounds in 1930 to 49.5 million pounds in 1962. In the same period, canned blueberries declined 13 percent, and frozen blueberries increased 142 percent. Large scale canning of blueberries in pie filling form began in 1955. Since then, the volume of canned pie filling increased from about 3.2 million pounds to about 8.8 million pounds in 1962, a 70 percent increase.

Total blueberry consumption has increased at a higher rate than population growth. Total consumption in 1929 amounted to 11.2 million pounds and in 1962, 85.6 million pounds, an increase of 546 percent. Average per capita consumption of blueberries increased significantly from .11 pounds in 1929 to .46 pounds in 1962, an increase of 318 percent. Per capita consumption of processed blueberries increased from .23 pounds in 1930 to .32 pounds in 1962.

Consumption of blueberries is proportionately higher in regions close to production areas. Between 1952 and 1956 the average per capita consumption of fresh blueberries in Michigan amounted to .82 pounds, commercially processed .6

pounds, canned .35 pounds and frozen .04 pounds.

U.S. processing of the blueberry crop has dipped from 88.9 percent of the total crop in 1954 to 64.3 percent in 1962. However, the total volume of blueberries processed increased from 27,099,000 pounds in 1950 to 43,551,000 pounds in 1962, an increase of 79 percent.

Blueberries sold in fresh forms are principally cultivated blueberries from Michigan, New Jersey, and North Carolina. These three states supply about 95 percent of the blueberries going to fresh market. Consumption of fresh blueberries is concentrated near the area of production. Over 80 percent of the unloads of fresh blueberries were reported in 5 cities, New York, Boston, Philadelphia, Detroit, and Chicago, and 93 percent in these and 5 additional cities.

During the period 1953 to 1957 about 37 percent of families in Michigan purchased commercially prepared apple and cherry pies, while only 22.4 percent of families bought commercially prepared blueberry pies. On the average, apple and cherry pies accounted for 63.6 percent of all fruit pies purchased by each person in Michigan, while blueberry pies accounted for a little over 10 percent. In 1957 82 percent of Michigan families bought no blueberry pies, 12 percent purchased blueberry pies once, and only 4 percent bought pies three or more times. The price of all types of fruit pies averaged 38 cents per pound. The price of blueberry pies was consistently above the prices of other fruit pies and the

average prices of all fruit pies. Blueberry pie price averaged 42 cents per pound between 1953 and 1957.

A study on commercially prepared fruit pies indicated that based on the average price and quantity, a 10 percent change in the average price of fruit pies was associated with about 21 percent change in the quantity consumed in the opposite direction. Thus if the prices of blueberry can be reduced to a price comparable to other fruit pies, such as cherry and apple pies, it is likely that blueberry pie purchases would increase.

Thus, after considering the factors above, studies of some potential new processing methods were undertaken to determine the feasibility of their use to possibly reduce cost of processing, storage, packaging and distribution, and therefore to increase the sales of the blueberry products.

In this study, products from two new processing technologies were considered, the dehydrofreezing process and the explosive-puffing process. Dehydrofreezing is a method of food preservation which involves drying the commodity to approximately 50 percent of fresh weight before freezing. The main advantage of this method is the reduction in weight and bulk of the product while quality is maintained. As a result of the reduced weight and bulk, packaging, storage and shipping costs are also reduced. In addition, reduction of drips upon thawing and the ease of controlling the moisture content are the advantages of dehydrofrozen products over

frozen items. Though plant investment for dehydrofreezing technology is higher than for freezing, the difference in cost is more than offset by the reduction in packaging, storage and transportation costs. In effect, the objective of dehydrofreezing is to obtain some of the economics of dehydration while maintaining the quality of the frozen product.

The explosive-puffing process is a new process which produces relatively larger dehydrated fruit and vegetable pieces that can be dehydrated and rehydrated more rapidly than the conventional dehydration process. Quick-cooking dehydrated fruits and vegetables have certain advantages over canned and frozen products. Quick-cooking dehydrated products have less weight and bulk and therefore storage, shipping and packaging costs are also reduced. Larger fruit and vegetable pieces are rehydrated easier, better and faster.

Each of these two new processing techniques (dehydrofreezing and the explosive-puffing process) yield products which might be adaptable for use in many types of blueberry products, i.e., for use in pies, muffins, jellies and others.

Products from each of the processing technologies were produced under laboratory conditions expressly for use in the consumer preference panels. Each of the technologies were at early stages of development. In each case, it was the first season on which either of the technologies have been attempted on blueberries even on an experimental basis.

Each new product type was primarily tested against standard products in only one final form. The quick-cooking dehydrated blueberries from the explosive-puffing process were tested against canned blueberries in muffin form and the dehydrofrozen blueberries were tested against normally frozen blueberries in pie form. Quick-cooking blueberries in pie form were compared to canned blueberries and frozen blueberries. The Michigan State University Consumer Preference Panel was used to test the quality of the products in muffin and pie forms.

Normally frozen blueberries were compared to dehydrofrozen control (no treatment) dehydrofrozen pricked, and dehydrofrozen nicked in pie form. The consumer preference tests indicated highly significant preference for normally frozen blueberry pies over both the dehydrofrozen control and the pre-treated dehydrofrozen blueberries, but no significant differences between the control and pre-treated dehydrofrozen in pie form.

In a triangle test comparing pies from the dehydrofrozen control to dehydrofrozen pricked blueberries, the discernment of differences was significant but the preferences between the two forms were not significant.

In two triangle tests comparing muffins made from quick-cooking and ordinary canned blueberries, there was a significant discernment of differences but a non-significant preference. Thus under conditions of the test, the quick-cooking

blueberries prepared by the explosive-puffing process were as acceptable as the normally canned blueberries in muffin form. However when the data were combined, the difference in preference was barely significant.

A consumer preference panel screening test was conducted of blueberry pies made from frozen, canned and quick-cooking blueberries. In this test the quick-cooking blueberries were ranked the lowest by a significant number of consumers. Due to the limited quantity of quick-cooking blueberries only a few experimental recipes were tested before the consumer panel was conducted.

Though dehydrofrozen blueberry pies were not as acceptable as normally frozen blueberry pies, consumer preference tests should be continued. The success of dehydrofrozen apples¹ and favorable results in consumer preference test on dehydrofrozen peas,² and the savings realized from packaging, storage and distribution costs would suggest that work on the dehydrofreezing process be continued. Better recipes on dehydrofrozen blueberries for use as pie fillings might be developed. The consistency of the pie may be improved and made uniform by measuring carefully the amount of water mixed with the pre-treated blueberries.

¹Greig, S.M., Grant and H.E. Larselore, "The Effect of Methods of Freezing Apple Slices on Consumer Preferences for Pies," C.S. Bulletin, May, 1960, pp. 42-89.

Greig, S., and W. Stuckman, "Market Potential for Dehydrofrozen and Dehydrocanned Apple Slices," Ag. Econ. Mines 601, September, 1960, pp. 1-51.

²Porter, et.al., loc.cit.

Talburt, et.al., loc. cit.

Even though the pies from quick-cooking dehydrated blueberries were ranked the lowest by a number of consumers, consumer preference tests should be continued. More trial pie filling recipes using quick-cooking blueberries is favorable before consumer preference tests are conducted again.

The quick-cooking blueberries, when used in muffins, were found acceptable by the consumer preference panel. This test is the initial step in pre-market testing. Mass consumer panel test, retail sales test, institutional sales test and demonstration-interview test may be conducted to determine consumer as well as institutional acceptance of muffins from quick-cooking blueberries. Quick-cooking blueberries may be tested on various popular recipes such as pancakes, coffee ring, cheese pie, monachnock pudding, shortcake, cream puffs, narmalade and ice cream.

Past studies suggest that at the retail level there exists a highly elastic demand for blueberry pies. Blueberry pies are typically priced higher than any one fruit pie. With these two factors in mind, the outlook for the dehydro-freezing process and the explosive-puffing process which both offer potential savings in packaging, storage and distribution costs are favorable. Thus, it is strongly suggested that further studies be conducted to improve the quality of and determine consumer acceptability of blueberry products processed from these two promising technologies, the dehydro-freezing and explosive-puffing, as well as any new technology that may appear feasible on blueberries.

APPENDIX A

Weighted Ranks of Consumer Preference (From Table 6.1)

Number of Items Ranked	Weight	Weighted Ranks			
		Normally Frozen	Dehydrofrozen (Control)	Dehydrofrozen Picked	Dehydrofrozen Picked
First	5	470	50	100	100
Second	4	100	212	154	143
Third	3	39	117	133	120
Fourth	2	26	82	70	96
Sum of Weighted Ranks (X)		635	471	479	464
Average Weighted Ranks(X) $\bar{X}$		512.3			
Deviations from Avg. $(X - \bar{X})$		122.7	41.30	31.30	48.30
Sq. of $(X - \bar{X})$		15,055.3	1,705.7	11,089.9	2,332.9
$\sum (X - \bar{X})^2$		30,182.8			
N		145			
N^2		21,025			
M		4			
M^2		64			

$$W = \frac{12 \sum (X - \bar{X})^2}{N(N-1)}$$

W =

$$= \frac{362,193.6}{21,025(60)}$$

=

$$= \frac{362,193.6}{12,61500}$$

=

$$= .287$$

W =

where

W = Coefficient of concordance

N = Number of individuals ranking the product

H = Number of products ranked

X = weighted rank

$\bar{X}$ = Average weighted rank

(b.) Chi-Square to determine significant differences among pie fillings.

$$\begin{aligned}\chi^2 &= N(\Sigma - 1)/v \\ &= 145(3) / 237 \\ &= 121.8\end{aligned}$$

The computed χ^2 , 121.8 is larger than the critical value found in (Kendall*) with $N = 1$ d.f. = 3 at .01 level of significance.

This indicates that the differences between the samples are highly significant and not due to chance.

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*Sources N.G. Kendall, Rank Correlation Methods, p. 189.

(c.) Chi-Square test to determine differences between all possible pairs of comparisons.

(1) Pies from normally frozen and dehydrofrozen control pie fillings.

Type of Pie Filling	Number of Pies Baked			
	1st	2nd	3rd	4th
Normally Frozen	94	25	13	13
Dehydrofrozen Control	12	53	39	41
Sum ($M_1 + M_2$)	106	78	52	54
Average ($\bar{X}$)	53	39	26	27
Observed - Inv.				
$(M_2 - \bar{X})$	41	14	13	14
$(M_2 - \bar{X})^2$	1,681	196	169	196
$\frac{(M_2 - \bar{X})^2}{\bar{X}}$	31.7	5.0	6.5	7.3
$\chi^2 = \frac{24(M_1 - \bar{X})^2}{\bar{X}}$				
$\chi^2 = 2(50.50)$				
$\chi^2 = 101.00$				

(2) Pies made from Dehydrofrozen control and dehydrofrozen mixed pie fillings.

Test of Pie Filling

	Number of Times Ranked			
	1st	2nd	3rd	4th

Dehydrofrozen Control (N_1)

Dehydrofrozen Mixed (N_2)

Sum ($N_1 + N_2$)

Average (N)

Observed - Average

$(N_2 - N)$

$(N_2 - N)^2$

$\frac{(N_2 - N)^2}{N}$

$\chi^2 = 2 \sum (N - N)^2$

$= 2(3.1)^2$

$= 6.2^*$

*No significant preference at .01 level of significance.

12	53	39	41
20	39	51	35
32	92	90	76
16	46	45	39
4	7	6	3
16	49	36	9
1	1.06	.80	.24

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(3) Pies made from dehydrated cream mixed and dehydrated cream prepacked pie fillings.

Time of Pie Filling

<u>Number of Times Ranked</u>			
<u>1st</u>	<u>2nd</u>	<u>3rd</u>	<u>4th</u>

Dehydrated Cream Mixed (N_1)

20 39 51 35

Dehydrated Cream Prepacked (N_2)

20 37 40 48

Sum ($N_1 + N_2$)

40 76 91 83

Average ($\bar{x}$)

20 38 45.5 41.5

Observed - Average

$(N_1 - \bar{x})$

0 1 5.5 -6.5

$(N_2 - \bar{x})^2$

0 1 30.25 42.25

$\frac{(N_2 - \bar{x})^2}{N}$

0 .026 .664 1.02

$\frac{\sum \frac{(N_2 - \bar{x})^2}{N}}{N}$

= 2(1.71)

= 3.42 *

*no significant preference at .01 level of significance.

(4) Pies made from dehydrofrozen control and dehydrofrozen pricked pie fillings.

Types of Pie Filling

Number of Times Ranked

1st	2nd	3rd	4th
-----	-----	-----	-----

Dehydrofrozen Control (M_1)

12 53 29 41

Dehydrofrozen Pricked (M_2)

20 37 60 43

Sum ($M_1 + M_2$)

32 90 79 89

Average ($\bar{x}$)

16 45 39.5 44.5

Observed - Average

$(M_2 - \bar{x})$

4 -8 .3 1.5

$(M_2 - \bar{x})^2$

16 64 .25 12.25

$\frac{(M_2 - \bar{x})^2}{\bar{x}}$

0 1.42 0.06 .28

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$$\chi^2 = \frac{2 \sum (M_2 - \bar{x})^2}{\bar{x}}$$

$$= 2(1.7)$$

$$= 3.4$$

no significant preference at .01 level of significance.

APPENDIX B

In the computation of the results of the triangle tests, the formulas below were used:

at the 5 percent level of significance,

$$y = N/3 + 0.5 + 0.9239 \sqrt{N}$$

at the 1 percent level of significance,

$$y = N/3 + 0.5 + 1.214 \sqrt{N}$$

at the one tenth percent level of significance,

$$y = N/3 + 0.5 + 1.551 \sqrt{N}$$

where:

y = is the observed number of correct answers at various levels of significance necessary to establish significant differentiation.

N = total number of tasters.

The above formulas were used in analyzing the answers to the first question of the triangle test, "which of y is greater than either the number of consumers who could differentiate and not differentiate the products correctly, then, there would be no significant difference between the two products tested.

In the analysis of the answers for the second question of the triangle test, the following formula was used:

$$y = \frac{N}{6} + 0.5 + \frac{Z \sqrt{N}}{6}$$

where:

N = total number of tasters.

Z = values of Z are 1.963, 2.576 and 3.090 at the 5 percent, 1 percent and .1 percent levels of significance, respectively.

y = minimum number of agreeing judgments necessary to establish significant preference,

This formula is used to analyse the second question, "which do you prefer, the identical or different sample?" of the triangle test,

If the value of y exceeds the number of consumers who preferred either of the two samples, then there would be no significant preference between the products,

If, however, both the number of consumers who preferred either of the two samples, taken separately, exceed the value of y , the result would mean that both products are significantly preferred. In this particular case, further analysis should be made by employing the formula below:

$$y = \frac{N}{2} + .5 + \frac{Z}{2} \sqrt{\frac{N}{2}}$$

where y and Z are the same as the values used in the preceding formula, while N represents the number of tasters who are able to distinguish correctly the two samples.

In a similar fashion, if the computed value of y exceeds the number of consumers of either of the two products, then there would be no significant preference between the two products.

APPENDIX C

Computation in Table 2.

Answer to No. 1 question:

at 5 percent level of significance

$$\begin{aligned}y &= n/3 + .5 + .9239 \sqrt{n} \\&= 139/3 + .5 + .9239 \sqrt{139} \\&= 46.33 + .5 + .9239 (11.789) \\y &= \underline{57.724257}\end{aligned}$$

at 1 percent level of significance:

$$\begin{aligned}y &= 139/3 + .5 + 1.214 \sqrt{139} \\&= 46.33 + .5 + 1.214(11.789) \\y &= \underline{61.144}\end{aligned}$$

There were significant differences between the two samples at both 5 and 1 percent levels.

where:

n = number of tasters (total).

y = minimum number of correct answer necessary to establish significant differences.

Answers to No. 2 question:

at 5 percent level

$$y = n/2 + .5 + \frac{z \sqrt{n}}{2}$$

where:

y = minimum number of tasters which prefer either samples necessary to establish significant difference.

n = number of tasters who were able to correctly differentiate the samples.

z = values that would vary from every level of significance.

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$$\begin{aligned}
 y &= 63/2 + .5 + \frac{1.960 \sqrt{63}}{2} \\
 &= 34 + .5 + \frac{1.96(8.246)}{2} \\
 &= 34 + .5 + \frac{16.162}{2} \\
 &= 34.5 + 8.8 \\
 &= \underline{43.31}
 \end{aligned}$$

Compared to the observed value of 36, there is no significant difference.

at 1 percent level.

$$\begin{aligned}
 y &= 63/2 + .5 + \frac{2.576 \sqrt{63}}{2} \\
 &= 34 + .5 + \frac{2.576(8.246)}{2} \\
 &= 34.5 + \frac{21.241696}{2} \\
 &= 34.5 + 10.620 \\
 &= \underline{45.121}
 \end{aligned}$$

No significant difference.

APPENDIX D

Computation for Table 4.1

Question number 1:

at 1 percent level

$$\begin{aligned} y &= N/3 + .5 + 1.214\sqrt{N} \\ &= 156/3 + .5 + 1.214\sqrt{156} \\ &= 52.5 + .5 + 1.214(12.49) \\ &= \underline{67.65295} \end{aligned}$$

Minimum number of tasters required to establish significant difference.

Compared with 99 tasters in the experiment, we can say that there was a significant or distinguishable difference between the two types of samples.

Question No. 2:

at 1 percent level

$$\begin{aligned} y &= N/2 + .5 + \frac{2\sqrt{N}}{2} \\ &= 99/2 + .5 + \frac{2.576\sqrt{99}}{2} \\ &= 49.5 + \frac{2.576(9.949)}{2} \\ &= 49.5 + \frac{25.628524}{2} \\ &= 49.5 + 12.814 \\ &= \underline{62.314} \end{aligned}$$

No significant difference.

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APPENDIX B

Computation for Table 4

Answer to question 1:

at 1 percent level

$$\begin{aligned} y &= N/3 + .5 + 1.214 \sqrt{N} \\ &= 147/3 + .5 + 1.214 \sqrt{147} \\ &= 49.5 + 1.214(12.124) \\ &= \underline{64.2} \end{aligned}$$

Comparing this value with the observed value (99), we concluded that there was significant difference.

Answer to question 2:

at 1 percent level

$$\begin{aligned} y &= N/2 + .5 + \frac{2 \sqrt{N}}{2} \\ y &= 101/2 + .5 + \frac{2.576 \sqrt{101}}{2} \\ &= 50.5 + .5 + 2.576(10.099) \\ &= 50.5 + .5 + 13.74 \\ &= \underline{64} \end{aligned}$$

Not significant; no significant difference.

APPENDIX F

Computation for Table 6.3

Answer to question No. 1:

at 1 percent level of significance

$$\begin{aligned} y &= n/3 + .5 + 1.214 \sqrt{303} \\ &= 303/3 + .5 + 1.214 (17.406) \\ &= 101 + .5 + 21.130834 \\ &= \underline{122.63} \end{aligned}$$

When compared to the observed value 202, there is a significant difference between the two types of samples.

Answer to question No. 2:

at 5 percent level

$$\begin{aligned} y &= n/2 + .5 + \frac{z \sqrt{n}}{2} \\ &= 202/2 + .5 + \frac{z (14.212)}{2} \\ &= 101 + .5 + \frac{1.960 (14.212)}{2} \\ &= 101 + .5 + 213.927 \\ &= \underline{115.427} \end{aligned}$$

significant difference.

at 1 percent level

$$\begin{aligned} n/2 + .5 + \frac{2.576 \sqrt{202}}{2} \\ 101 + .5 + \frac{2.576 (14.212)}{2} \\ 101 + .5 + 18.305 \\ \underline{119.805} \end{aligned}$$

significantly different.

APPENDIX G

Weighted Ranks of Consumer Preference

Computation for Table 6.6.

No. of Times Ranked	Height	Type of Pie Filling		
		Canned	Frozen	Quick- Cooking
Weighted Ranks				
First	3	420	130	53
Second	4	164	264	96
Third	3	18	87	238
Sum of Weighted Ranks (Σ)		602	531	439
Ave. Weighted Ranks ($\bar{x}$)		524		
Deviations from Ave ($x - \bar{x}$)		73	7	-63
Sq. of ($x - \bar{x}$)		6,024	49	7,225
$(x - \bar{x})^2$		12,359		
Σ		131		
Σ^2		17,161		
Σ		3		
Σ^3		27		

$$W = \frac{12 \sum (X - \bar{X})^2}{N^2(N^2 - 1)}$$

$$= \frac{12(12359)}{17161(27-3)}$$

$$= \frac{150228}{411,864}$$

$$= .369$$

where:

W = coefficient of concordance

N = number of individuals ranking the products

n = number of products ranked

X = weighted rank

$\bar{X}$ = average weighted rank

(b) Chi-square test to determine significant difference among pie fillings

$$\begin{aligned}\chi^2 &= N(\sum \frac{f^2}{n} - 1) \\ &= 121(2).339 \\ &= (242).339 \\ &= 81.5\end{aligned}$$

$$\begin{aligned}k &= (n - 1) \\ &= (3 - 1) \\ &= 2\end{aligned}$$

Compare χ^2 or computed value of χ^2 with the critical value of χ^2 in the Table*, $N-1$ degrees of freedom, at .01 level.

Value found in Table is 9.21.

The computed χ^2 is larger than the critical value and this means the differences between the samples were highly significant, and not due to chance. This also indicates that there is a significant difference between the highest weighted rank and the lowest weighted rank of the three types of pie fillings.

* Source of value (critical), H. G. Kendall, RANK CORRELATION Method, p. 189.

(c) Chi-square test to determine differences between all possible pairs of comparisons.

(1) Canned and frozen compared:

<u>Type of Pie Filling</u>	<u>Number of Times Ranked</u>		
	<u>First</u>	<u>Second</u>	<u>Third</u>
Canned (N_1)	64	41	6
Frozen (N_2)	35	65	29
Sum ($N_1 + N_2$)	120	107	35
Average ($\bar{x}$)	60	53.5	17.5

Observed - Average

$(N_1 - \bar{x})$	24	12.5	11.5
$(N_1 - \bar{x})^2$	576	156.25	132.25
$\frac{(N_1 - \bar{x})^2}{\bar{x}}$	9.6	2.9	7.5

$$\chi^2 = 2 \sum (N - \bar{x})^2$$

$$\chi^2 = 2(20) = 40$$

(2) Frozen and quick-cooking pie

<u>Type of Pie Filling</u>	<u>Number of Times Ranked</u>		
	<u>First</u>	<u>Second</u>	<u>Third</u>
Frozen (N_1)	38	66	29
Quick-cooking (N_2)	11	24	96
Sum ($N_1 + N_2$)	47	90	125
Ave. ($\bar{x}$)	23.5	49	62.5

Observed - Ave.

$(N_1 - \bar{x})$	-12.5	-21	33.5
$(N_1 - \bar{x})^2$	156.25	441	1122.25
$\frac{(N_1 - \bar{x})^2}{\bar{x}}$	6.63	9.0	17.9

$$\chi^2 = 2 \sum \frac{(n_{12} - x)^2}{x} = 2(34.33)$$

$$= 2(34.33)$$

$$= 68.66$$

(3) Canned and quick-cooking.

Type of Pie Filling	Number of Times Ranked		
	First	Second	Third
Canned (n_1)	84	41	8
quick-cooking (n_2)	11	24	96
Sum ($n_1 + n_2$)	95	65	102
Avg. ($\bar{x}$)	47.5	32.5	51.0
(Observed - Avg.)			
$(n_{12} - \bar{x})^2$	-33.5	-8.5	45
$(n_{22} - \bar{x})^2$	1332.2	72.2	2025
$\frac{(n_{22} - \bar{x})^2}{x}$	28	2.2	39.7

$$\chi^2 = 2 \sum \frac{(n_{22} - \bar{x})^2}{x}$$

$$= 2(69.9)$$

$$= 139.8$$

With $(N - 1) = 2$ and at .01 level of significance, the critical value found in Kendall is 5.991.

∴ (Canned) pies were significantly preferred over frozen and quick-cooking pies. Pies from frozen were significantly preferred over quick-cooking pies.

Bibliography

- Applebaum, W. and Spears, R. "Controlled Experimentation in Marketing Research," The Journal of Marketing, XIV (1950).
- Bedford, C.L., and Robertson, W.F. "Effect of Pretreatments on the Quality of Frozen Blueberries," Quick Frozen Foods, XVII, No. 53, (1954).
- "The Big Challenge to Food Marketing," This Week Magazine, 1959.
- Bitting, A.W., and Bitting, K.G. Canning and How to Use Canned Foods, Washington, D.C.: National Capital Press, Inc., 1916.
- Bissette, O.W., Tatum, J.H., Wagner, C.J., Veldhuis, M.K., Graham, R.F. and Morgan, A.I. Jr., "Foam - Mat Dried Orange Juice," Food Technology, XVII, No. 2, (1963).
- "Blueberries," Food Marketonics, Michigan State University, June 9, 1961.
- Boggs, Mildred and Talbert, W.F. "Comparisons of Frozen and Peas with Fresh and Stored Pod Peas," Food Technology, VI (1952).
- Bonnell, J.M., Stroschum, S.I., and Dorsey, W.R. "Commercial Production of Orange and Grapefruit Crystals," Florida State Horticulture Society, (1955).
- Boucher, R.M.G. "Ultra-sonic Boosts Heatless Drying", Chemical Engineering, (September 21, 1959).
- Braun, E. "Frozen Stuffed Peppers: A New Frozen Food?" South Carolina Experiment Station Report No. 127, Clemson: Department of Agricultural Economics (1957).
- Burk, M.C. Consumption of Processed Farm Foods in the United States, U.S. Department of Agriculture Marketing Research Report No. 409, Washington, U.S. Government Printing Office, 1960.

Campbell Soup Company Annual Report, Fiscal Year, 1957.

Canner/Packer Yearbooks, 1960-1962.

Consumer Preference for Frozen Peas in Relation to Standards for Cudes,

Marketing Research Report No. 280, U.S. Department of Agriculture,
AMS, 1958.

Consumption of Food in the United States, 1909-1952, U.S. Department
of Agriculture, Economic Research Service, Agricultural Handbook
No. 62, Washington: U.S. Government Printing Office, 1961.

Consumption Trends and Patterns for Vegetables, Potatoes, Sweet
Potatoes, Dry Beans and Peas, U.S. Department of Agriculture,
Agricultural Handbook No. 215, Washington: U.S. Government
Printing Office, 1961.

Copley, M.J. "The Outlook for Freezing and Dehydrofreezing in Food
Preservation," Paper presented at the Meeting of American
Society Refrigeration Engineers, Chicago, November 14, 1957.

Copley, M.J., Kaufman, V.F., and Rasmussen, C.L. "Recent Development
in Fruits and Vegetables Powder Technology," Food Technology,
X, (1956).

Cording, J. Jr., and Eskew, R.K., U.S. Patent 3,038, 813 (June 1962).

Cording, J. Jr., Eskew, R.K., Sullivan, J.F., and Eisenhardt, N.J.
"Quick-cooking Dehydrated Vegetables: Carrots and Beets,"
Food Engineering, XXXV, No. 6 (1963).

Cording, J. Jr., Willard, M.H. Jr., Eskew, R.K. and Sullivan, J.F.
"Advances in Dehydration of Mashed Potatoes by the Flake Process,"
Food Technology, IX (1957).

Croxton, F. and Cowden, D. Applied General Statistics, Englewood
Cliffs, New Jersey: Prentice-Hall, Inc., 1956.

Darymple, D.J. A Survey of Applesauce Preference, Cornell University Experiment Paper No. 7, Ithaca, New York: Cornell University Press, 1959.

Dwarkin, P.R. and Jacobs, M. Potato Flakes: A New Form of Dehydrated Mashed Potatoes: Market Penetration and Consumer Acceptance in Binghamton Endiscott and Johnson City, New York, U.S. Department of Agriculture, Marketing Research Report No. 186, Washington: U.S. Government Printing Office (1957).

Eisenhardt, N.H., Cording, J.Jr., Eskew, R.K., and Sullivan, J.F. "Quick-cooking Vegetable Pieces," Food Technology, XVI (May, 1962).

Eisenhardt, N.H., Eskew, R.K., and Cording, J.Jr. "Explosive-Puffing Process Applies to Apples and Blueberries," (Manuscript Submitted to Food Engineering).

Eskew, R.K., Drazga, P.J., Cording, J.Jr., Sullivan, J.F. and Woodward, C.F. "Potato Flakes: V. Potato Flakes of Increased Density," U.S. Department of Agriculture, ARS 73-30, 1960.

French, B.C. "Some Economic Aspects of Pie Consumption," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, EastLansing, Michigan, XLI (February, 1959).

French, B.C. "Trends in Blueberry Consumption," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University East Lansing, Michigan, XL (August 1957).

Garnatz, G. "But What Do The Consumers Say?" Food Industries, XVII (1950).

Ginnette, L.F., Geaham, L.L., and Morgan, A.I. "Process of Dehydratin Forms," Patent No. 2,981,629.

- Goldblith, S.A. "Radiation Preservation of Foods --- Two Decades of Research and Development," Radiation Research, Proceedings of an international conference commemorating the operational availability of the U.S. Army Radiation Laboratory, Massachusetts, January 14-16, 1963.
- Greig, W. Smith. "Market Development For Cherries," Talk given to cherry growers at Traverse City, Hart, and Benton Harbor, Michigan, October 3, 4, and 5, 1962, respectively.
- Greig, W.S. Market Potential for Dehydrofrozen and Dehydrocanned Apple Slices, Department of Agricultural Economics Mimeo No. 801, East Lansing: Michigan State University, 1960.
- Greig, W.S. The Restaurant, Hotel and Institutional Market for Dehydrated Mashed Potatoes, Michigan State University, Preliminary Report, East Lansing: Department of Agricultural Economics, 1957.
- Greig, W. Smith, Grant, M.E., and Larzelere, H. "The Effect of Methods of Freezing Apple Slices on Consumer Preference for Piece," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, XLII, No. 4, (May 1960).
- Greig, W.S., and Larzelere, H. "Consumer Taste Preferences Among Dehydrated Mashed Potato Products," National Potato Council News, V (February 1957).
- Greig, W.S., Strand, F.C., and H.E. Larzelere, Relative Retail Sales and Elasticity of Demand for Dehydrated Mashed Potato Product, Michigan State University, Department of Agricultural Economics, Mimeo 732, E. Lansing; Department of Agricultural Economics 1958.
- Greig, W. Smith and Stuckmann, N.W. Market Potential for Dehydrofrozen and Dehydrocanned Apple Slices, Agricultural Economics Mimeo 801, East Lansing, Michigan: Agricultural Economics Department

Michigan State University, September 1960.

Greuess, P. "Drying by Airborne Ultrasonic", Ultrasonic News, Fall 1961.

Heid, J.L. and Kelly, E.J. "The concentration and Dehydration of Citrus Juices," Cannery, CXVI, Nos. 5 and 6 (1953).

Hunter, J. Scott. "Consumer Preference for 6 to 1 Apple Juice Concentrate," Marketing Research Report, No. 343, U.S. Department of Agriculture, AMS, 1959.

Harrie, R.G. and Dvoskin, P.B. "Convenience Foods and Their Cost to Consumers," The Marketing and Transportation Situation, July 1956.

Kaufman, V.P. and Powers, M.J. "How Dehydrofrozen Cuts Packaging and Shipping Costs on Processed Fruits," Food Engineering, No. 1 (1957).

Kaufman, V.P., Wong, F.F., Taylor, D.H., and Talburt, W.S. "Problems in the Production of Tomato Juice Powder by Vacuum," Food Technology, IX (1955).

Keller, J. J., Rice, R.G., and McCollack, R.J. "A Low Temperature-concentrated Tomato Juice," Western Canner and Packer, No. 8 (1952).

Kendall, M.G. Rank Correlation Method, New York: Halfter Publishing Company, 1955.

Kiehl, E.R., and Rhodes, James. "New Technique in Consumer Preference Research," Journal of Farm Economics, XXXVIII (1955).

Larselene, H.E., and Gibbs, R.D. "Consumer's Opinion of Quality in Pork Chops," Quarterly Bulletin, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, XXXIX, No. 2 (November 1956).

- Lockhart, E.E. and Gaines, J. M. "Acceptance of Fresh, Frozen and Canned Orange Juices," Food Research, XIV (1949).
- Marine, L. "Testing Institutional Acceptance of New Food Products by Means of An Institutional Sales Test," Unpublished Manuscript Department of Agricultural Economics, Michigan State University, 1962.
- Maguire, J.F. "Freeze-Drying Moves Ahead in U.S.," Food Engineering, (August, 1962).
- McClaskey, G.T. "A Look Blueberry Market," Blueberry Research. Fifty Years of Progress, New Jersey Agricultural Experimentation Rutgers, (July, 1960).
- McCreary, E.K. "The Use of Demonstration Interview Technique in Estimating the Institutional Acceptance of Dehydrated Washed Potatoes," Unpublished Master's thesis, Department of Agricultural Economics, Michigan State University, 1962.
- McBrath, E.J. and Sills, M.S. Restaurant Acceptance of Dehydrated Potatoes, U.S. Department of Agriculture Marketing Research Report No. 193, Washington: U.S. Government Printing Office, 1957.
- Meyers, T. "Predicting Market Acceptance," Journal of Farm Economics, XXXVII (1955).
- Michigan Blueberry Growers Association, Grand Junction, Michigan. Personal interview with Mr. Pete Holbein, General Manager, October 1963.
- Michigan Public Service Commission, Opinions and Orders, Docket 2-34 75, Supplement Order No. 6, April 1960.
- Michigan State University, East Lansing, Michigan. Personal interview with Mr. Clifford Bedford, Professor, Department of Food Science, 1963.

- Miller, P.G., Nair, H.H., and Harriman, A.J. "A Household and a Laboratory Type of Panel for Testing Consumer Preference," Food Technology, IX (1955).
- Morgan, A.I. Jr., and Kaufman, V.F. "Tumbling Freeze-Dryer Promises Advantages," Food Engineering, (November, 1962).
- Nair, John H. "Mass Testing Panels," Food Technology, 111 (1949).
- National Motor Freight Traffic Association, National Motor Freight Classification, September, 1963.
- Natter, G.K., Taylor, D.H., and Dreke, J.E. "Pineapple Juice Powder," Food Technology, IX (1956).
- Platt, Washington. "How Will Consumers Rate Your Products?", Food Industries, IX (1937).
- Powell, Oia. Successful Canning and Preserving, Philadelphia: J.B. Lippincott Company, 1913.
- Prescott and Sweet. "Commercial Dehydrations: A Factor in the Solution to the International Problems," Annual American Academy of Political and Social Science, No. 1294, (1919).
- "Railroad Offers Incentive Rates to Induce Frozen Food Freights," Quick Frozen Foods, (August, 1963).
- Rasmussen, C.L., Venstrom, D.W., Newman, H.J., Olson, R.L., Rockwell, W.C., and Strong, K. "Latest Dehydrofrozens Cut Costs," Food Engineering, December 1957.
- Rauch, A.C. "Government Program For Freeze-Dried Foods," Food Processing Review, Oregon State University (December 7, 1962).
- Scott, F.S. Frozen Passion Fruit Juice. An Appraisal of the Mainland Market, Hawaii Agricultural Experiment Station Report No. 25, Honolulu: Department of Agricultural Economics, 1955.

- Scott, F.S. Jr., "Seasonability of Purchases of Frozen Orange Juice Concentrate, Frozen Lemonade Base, and Frozen Passion Fruit Juice, Hawaii Farm Science, VII (January, 1959).
- Shaffer, J.D. Consumer Purchase Patterns for Individual Fruits and Vegetables, M.S.U. Consumer Panel 1952-1953, Consumer Panel Bulletin No. 8, Michigan State University, 1962.
- Siu, Ralph, G.H., "The United States Program of Radiation-Preservation of Foods," Radiation Research, Proceedings of an International Conference commemorating the operational availability of the U.S. Army Radiation Laboratory, Natic, Massachusetts, January 14-16, 1963.
- Stare, Fred. The Story of Wisconsin's Great Canning Industry, The Canning Trade, November, 1949.
- Sullivan, J.F., Cording, J. Jr., and Eskew, R.K. "Quick-cooking Dehydrated Sweet Potatoes," Food Engineering, XXIV, No. 11 (1963)
- Talburt, W.F., and Legault, R.R. "Dehydrofrozen Peas," Food Technology IV (1950).
- Talburt, W.F., Walker, L.H., and Powers, M.J. "Dehydrofrozen Apples," Food Technology, IV (1957).
- Tressler, Donald and Evers, Clifford. The Freezing Preservation of Food, Volume 1, Connecticut: The Avi Publishing Company Incorporated 1957.
- U.S. Bureau of the Census, U.S. Census of Agriculture, 1929 to 1959.
- U.S. Department of Agriculture, Agricultural Statistics, 1962 and 1963.
- U.S. Department of Agriculture, The Fruit Situation, January 1961.
- Waldorf, W. Output of Factories Processing Farm Food Products in the United States, 1909-1953. U.S. Department of Agriculture Technical Bulletin, No. 1223, Washington: U.S. Government Printing Office, 1933.

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