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Low Water Volume Enzyme Deactivation of Vegetables Before Preservation

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May 1973

LOW WATER VOLUME ENZYME DEACTIVATION OF VEGETABLES BEFORE PRESERVATION

by

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Project 12060 PAV

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ABSTRACT

Four pilot-plant units were operated with asparagus, peas, corn, beans, beets, pumpkin, and spinach to establish the potential for new blanching systems with low wastewater generation. The systems investigated were microwave, hot-gas, steam and hot-water.

Single runs of about one hour duration were made for each commodity with each blanching system. Wastewater volume was measured and samples were analyzed for COD, SS, and pH. The most striking result obtained was the small volume of steam condensate formed during hot-gas blanching.

Canned samples of vegetable material from each blancher were prepared for quality evaluation after storage. Taste panels showed no significant flavor preference for samples from any individual blanching system. The system used had no significant effect on the vitamin and mineral retention of blanched or canned samples. The oxygen content of canned samples was lowest for hot-gas blanching compared to the other three systems.

Estimates of the cost of blanching using commercial-scale units gave (dollars/ton blanched): microwave, 18.47; hot-gas, 3.39; steam, 2.21; and hot-water, 2.36.

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FIGURES

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SECTION I

CONCLUSIONS

1. Two relatively new blanching systems, microwave and hot-gas, show promise for reducing enzymatic activity and removing occluded gases in asparagus, peas, beans, corn, beets, pumpkin and spinach.

2. The use of microwave blanching of vegetables reduces the volume of wastewater formed substantially, but the capital costs are too high for a seasonal operation.

3. A new method of blanching, now called "hot-gas blanching" shows exceptional promise in reducing wastewater volume to very low levels while providing commercially acceptable blanching.

4. The flavor of hot-gas blanched vegetables, preserved by canning, was not significantly different from the flavor of samples prepared by microwave, steam and hot-water blanching.

SECTION II

RECOMMENDATIONS

1. Hot-gas blanching of major-use vegetables should be investigated on an in-plant, continuous basis.

2. The hot-gas blanched vegetables investigated on an in-plant, continuous basis should be returned to commercial production either mixed or unmixed with conventionally blanched material.

3. The commercial product containing all or partially hot-gas blanched vegetable should be marketed in such a way that consumer reaction to the quality can be evaluated.

4. The interest of all potential equipment suppliers should be encouraged so the design and production of commercial-scale hot-gas blanchers will move forward rapidly if in-plant trials are successful.

SECTION III

INTRODUCTION

The heating of vegetables prior to terminal preservation by freezing, canning, or dehydration is an essential operation for satisfactory final product quality (1). This blanching treatment produces several desirable changes in the raw vegetables. Primarily, enzymes are thermally inactivated to stabilize the food components against rapid chemical changes. Gases, most importantly oxygen, are displaced from the food during blanching. For several vegtables, the blanching step results in physical changes in the vegtable which improves subsequent operations such as washing, peeling, or filling into containers. The blanching step may provide a useful removal of certain contaminants on, or in, the raw food.

The disadvantages in vegetable blanching using steam or hot-water are loss of nutrients and the formation of large volumes of high-strength liquid wastes. Surveys (2) of canneries have indicated that an average of 40 percent of the total BOD in the liquid waste from vegetable processing results from hot-water or steam blanching (Figure 1).

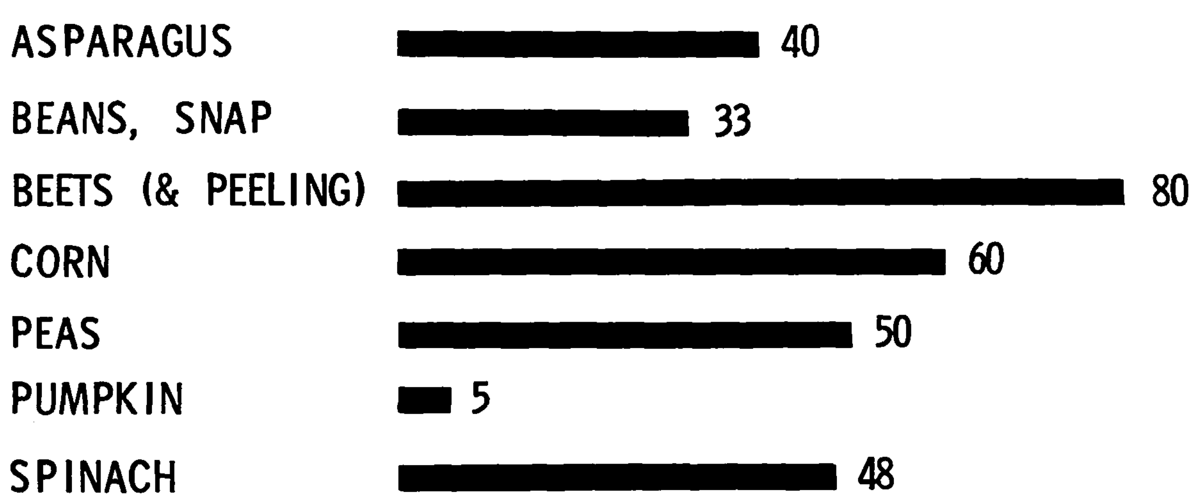

Figure 1. Percent of Total BOD Due to Blanching

New methods of blanching which generate lower volumes of liquid wastes during vegetable processing would have obvious advantages for environmental protection.

Blanching methods that minimize generation of liquid waste require heat transfer media of controlled low water content. Since vegetables are 70-92 percent water, the key to low wastewater blanching is adequate heat transfer with minimal condensate from the water in the vegetable or from injected steam,

The present practice of the vegetable preservation industry is to use hot-water or steam blanching. Relatively little research and development effort has been devoted to new or modified blanching systems which would reduce the volume of liquid waste generated. Two recent innovations in vegetable blanching methods have promise of substantial reductions in wastewater volume. However, neither of these systems [fluidized bed blanching (3) or IQB (4)] appear to have the potential for almost complete elimination of wastewater.

Two methods of blanching which have potential for low wastewater volume generation were chosen for a comparative study along with hot-water and steam blanching. One method, microwave blanching, has had prior investigation with several vegetables: corn-on-cob (5, 6), brussel sprouts (7) and potatoes (8). None of these earlier studies were as comprehensive as those planned in this current study. The second blanching system proposed for this study was a completely new method called hot-gas blanching which is based on the direct use of hot natural gas combustion products as the major heat source for increasing the temperature of the vegetables being blanched.

Therefore, the objectives of this study were to compare the traditional methods of vegetable blanching (hot-water or steam) with a partially evaluated (microwave) method and a new (hot-gas) method with the expectation of demonstrating feasibility of a low waste-water volume blanching system which gave adequate product quality and retention of nutrients. The four blanching systems studied were compared by measuring operational factors, pollutional potential, product quality, and cost estimates.

SECTION IV

EXPERIMENTAL PLAN

BLANCHING

To evaluate the potential usefulness of microwave and hot-gas blanching of seven major vegetable commodities, simulators of possible commercial-scale units were operated in conjunction with simulators of commercial hot-water and steam blanching equipment.

The microwave unit used in this study was a Varian Model COS 5A Microwave Conveyor shown schematically in Figure 2. The specifications for the microwave blanching unit are tabulated in Appendix A.

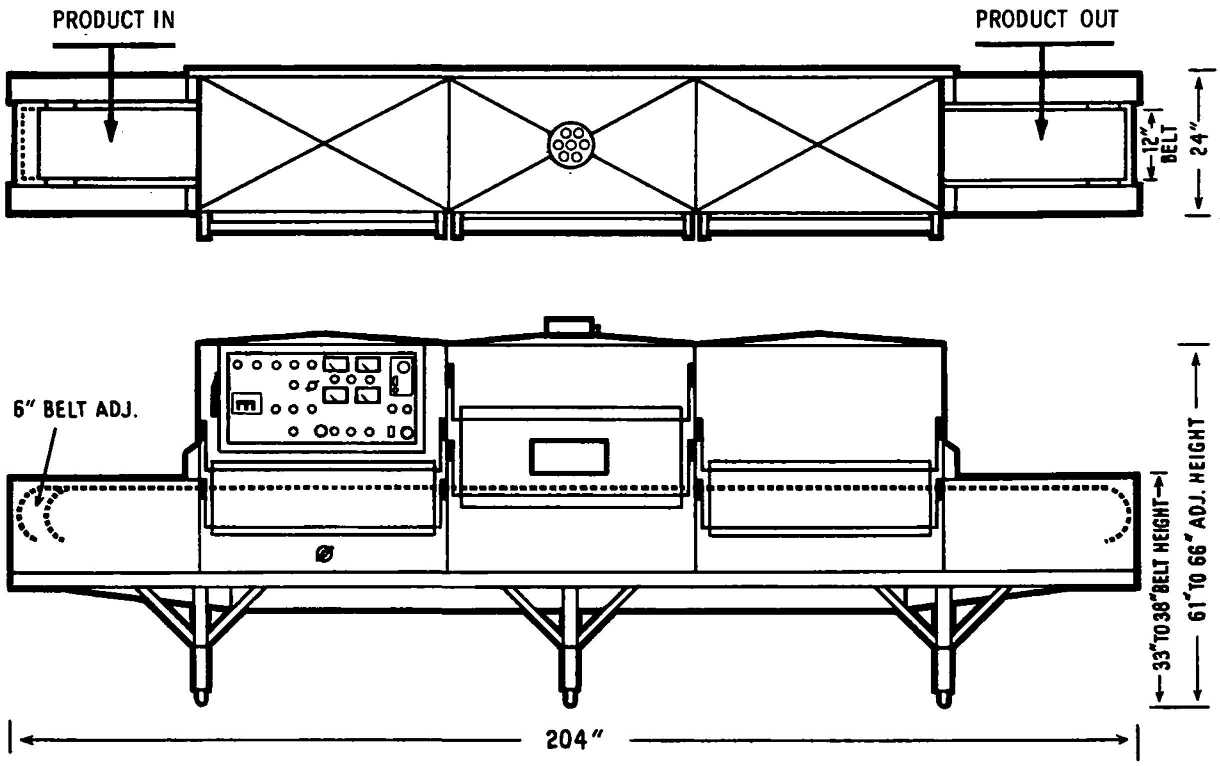

Figure 2. Microwave Blancher

The hot-gas blanching unit was designed, at the request of the National Canners Association, by Magnuson Engineers, Inc., and fabricated by Heat and Control, Inc. Outline drawings of the hot-gas blancher are shown in Figure 3.

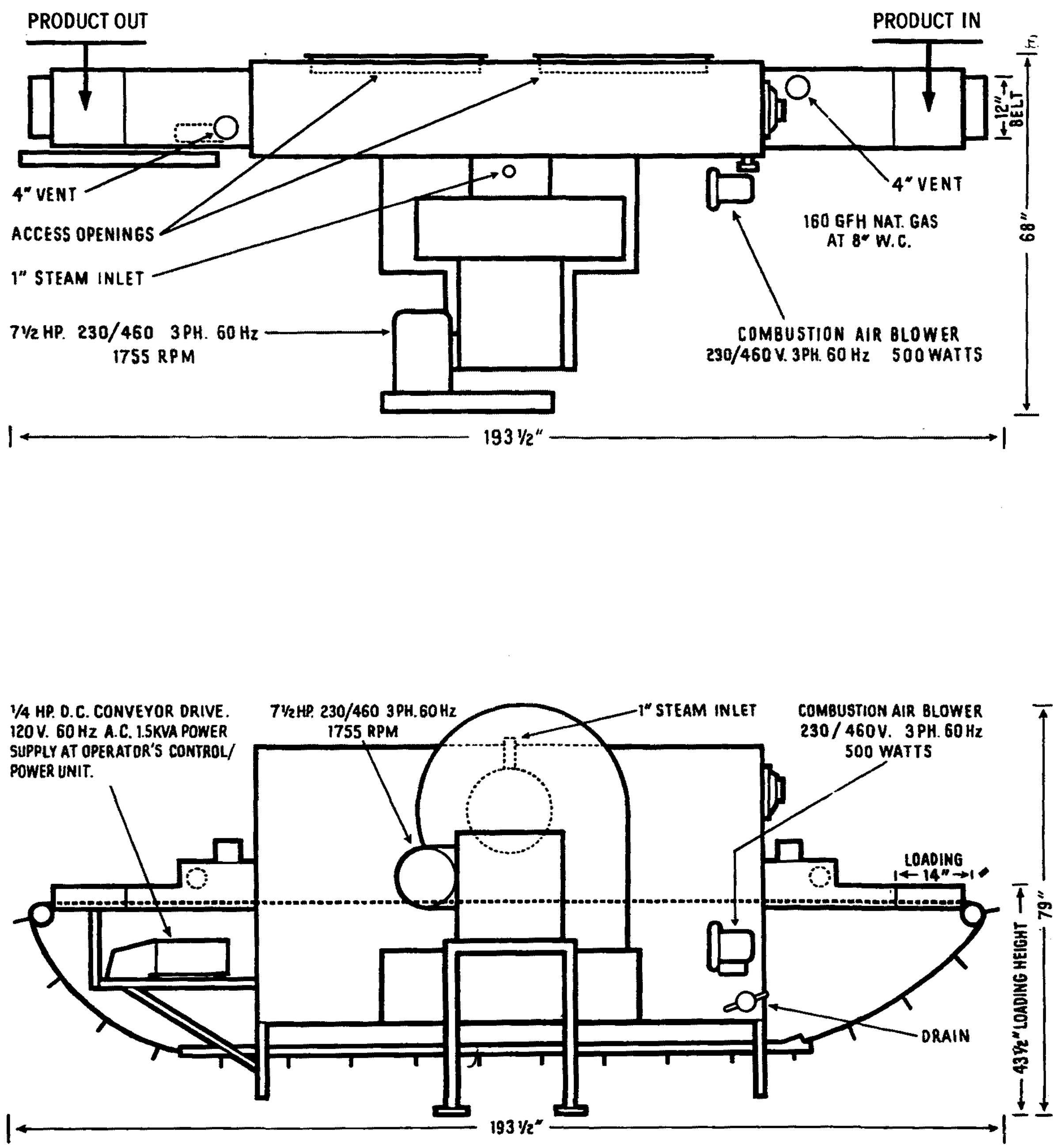

Figure 3. Hot-Gas Blancher

The specifications of the hot-gas blancher are shown in Appendix B. The hot-gas blancher generates a mixture of hot nitrogen, carbon dioxide and water (supplemented on occasion by injected steam) which is blown past the vegetable pieces as they are conveyed through the high temperature zone. The temperature of the vegetable pieces is raised by transfer of heat from the hot-gas mixture until a temperature is achieved which will thermally inactivate enzymes and drive off occluded gases. At this point, the heated vegetables are discharged to an ambient temperature zone and are conveyed to a filling line for canning or to a cooling line for frozen products. If sanitary conditions are maintained in the hot-gas blancher, no further washing of the blanched product before canning is required.

The steam and hot-water blanching was simulated in a single unit which was the third stage of the pilot washer provided to the National Canners Association under U.S. Atomic Energy Commission Contract AT (04-3) - 536. Line drawings for the steam and hot-water blancher are shown in Figure 4. The specifications for the steam and hot-water blancher are listed in Appendix C. The commercial practice of the vegetable preservation industry is to use hot-water or steam for blanching. Hot-water is an effective blanching medium due to its exceptional heat transfer properties, its cleansing action on soiled vegetables and its ease of temperature control. Steam blanching is used less frequently than hot-water blanching, usually in those cases where a quality factor (taste, color, texture) is improved by the use of steam.

Raw vegetables were donated by member canners and were transported by refrigerated truck to the Berkeley Laboratory where the blanching simulators were installed. A series of short duration experiments were conducted over a range of operating conditions for each blanching unit to determine good operating conditions. The conditions selected for longer duration experiments were based on weight changes, product appearance and residual peroxidase levels. The peroxidase measurement involved measuring color generation over a period of ten minutes. The plot of time versus optical density gave a line whose slope corresponded to residual peroxidase content (5).

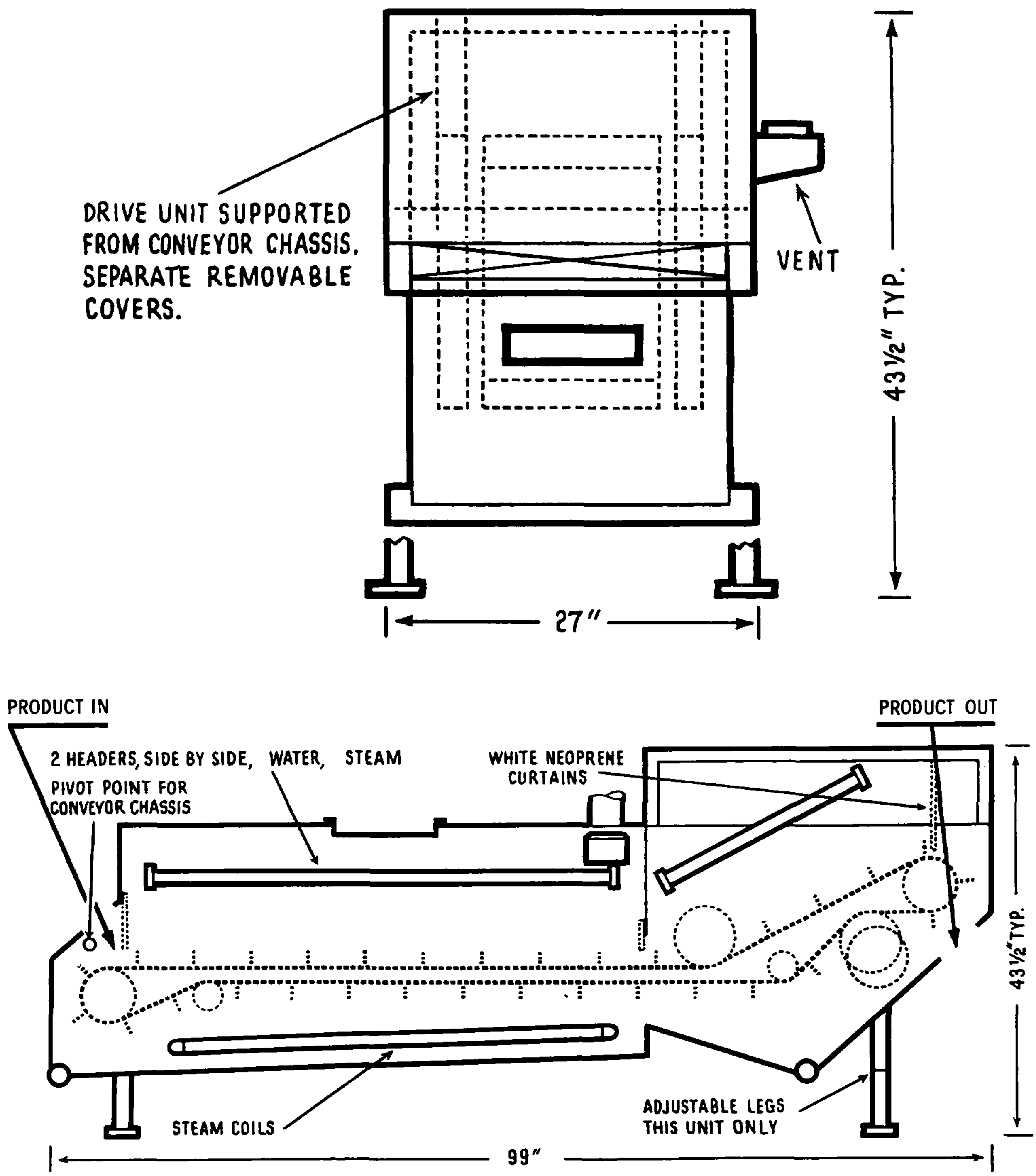

Figure 4. Hot-Water and/or Steam Blancher

The unit indicated in Figure 4 was operated as a steam blancher by passing steam into a spray head manifold above the conveyor belt. The unit was operated as a hot-water blancher by circulating a fixed volume of water held in the blancher tank through an automatically controlled (steam heated) tubular heat exchanger. A photograph of the blanching units as they appeared during the pilot plant studies is shown in Figure 5.

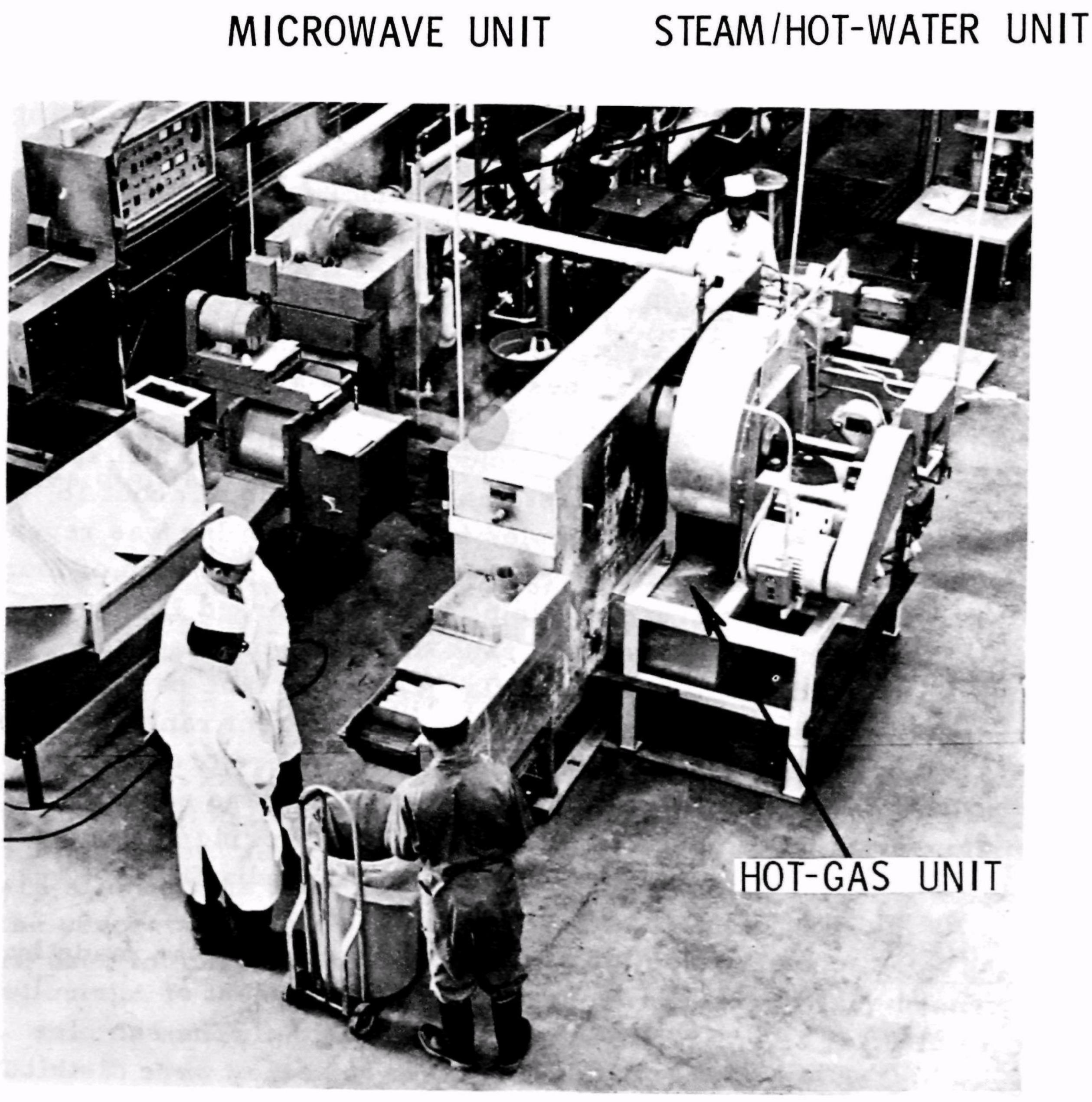

Figure 5. Pilot Blanching Installation

During the long duration runs, wastewater samples were collected from each of the four blanchers. The total effluent from the microwave, hot-gas and steam blancher was measured for volume and a portion analyzed. Four one quart samples of the total volume of mixed liquid and suspended solids were taken from the hot-water blancher at 15 min intervals. A final wastewater sample was taken from the hot-water blancher tank at the end of each long duration run for each of the vegetables studied. All of the wastewater samples collected were analyzed for COD, SS and pH (9).

PRODUCT EVALUATION

Samples of blanched vegetables were prepared (for example : corn cutting, beet peeling, pumpkin blending and screening) and canned for later quality evaluation. A total of five quality evaluations (taste, grading, headspace gases, internal can corrosion, and vitamin and mineral content) were made on each set of canned vegetable samples. Details of these evaluations are presented below.

Taste - Sets of samples of each commodity (except peas and spinach) were presented to a laboratory taste panel consisting of about 16 tasters. The presentation of samples in a random order was repeated four times to obtain approximately 60 judgements. The sets of four different samples were presented in paper cups marked L, M, N, and O. Each panelist was asked to rank the four samples after tasting, with "4" denoting the worst flavor, and "1" the best flavor. It was requested that each sample be a given different ranking number even if two or more samples tasted the same. Therefore, if four identical samples were judged, the cumulative average score for a large number of judgements would be "2. 5." A scoring sheet used to record the ranking of samples is shown in Appendix D.

Grading - A second evaluation of the canned samples was made by experienced quality graders from the U.S. Department of Agriculture Processed Fruit and Vegetable Inspection Division. The samples were shipped to Stockton, California from where they were distributed by the USDA to individual inspectors. This quality grading developed a number reflecting primarily the appearance of the sample.

Headspace Gases - Limitation of time did not permit a direct measure of gas content of vegetables immediately after blanching. An analysis was made of headspace gas in cans representing each blanching variable for each commodity. The method used was essentially that described in the NCA Laboratory Manual for Food Canners and Processors (10) with the modifications listed in Appendix E.

Internal Can Corrosion - The fourth quality evaluation was made by visual examination of 7-14 washed and dried empty cans from each blanching variable for extent of internal corrosion. The cans were scored "4" if badly corroded, "3" if moderately corroded, "2" if slightly corroded and "1" if without visible corrosion.

Vitamin and Mineral Content - The fifth quality measurement was the determination of the level of vitamins and minerals in raw and blanched samples of each vegetable studied, restricting the analysis to the nutritionally significant components. These determinations were made according to the Eleventh Edition of the "Official Methods of Analysis of the Association of Official Analytical Chemists" (11).

The selection of vitamins and minerals for analysis was based on three sources of data:

a) Tabulations of vitamin and mineral content of raw and processed vegetables (12, 13)
b) Official tabulations of Recommended Daily Dietary Allowances (14)
c) Per capita consumption of processed vegetables (15)

In general, a vitamin or mineral was included in the analytical schedule if a 100 g portion of a specified vegetable contained 10% or more of the maximum recommended daily dietary allowance, (MRDA). In those cases where all vitamins and minerals were below the 10% figure, a combination of the percentage contribution to the MRDA and the per capita consumption were used to make the selection.

The vitamin and mineral testing schedule used in this study is tabulated in Table 1. Due to loss of samples or misunderstandings on the part of analysts, this schedule was not followed rigorously.

Table 1 Schedule of Analysis for Vitamins and Minerals

Commodity	Vitamins						Minerals			
	A	B_1	B_2	B_6	C	Niacin	Ca	Mg	P	Fe
Asparagus	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
Green Beans	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Beets	No	No	Yes	No	Yes	Yes	No	No	Yes	No
Corn	No	Yes	Yes	Yes	No	Yes	No	No	Yes	No
Peas	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pumpkin	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No
Spinach	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes

STATISTICAL EVALUATION

The results of product evaluations were subjected to analysis of variance to determine if there was a significant effect due to the the blanching condition used in the preparation of samples on which the measurement was made. The analysis of variance was made using a randomized complete block design (16) with the vegetables involved in the analysis as blocks and the blanching conditions as treatments. When the variance ratio (F value) calculated exceeded the tabular F values at the 1 or 5 percent level of significance, multiple range tests could be used to determine significance due to individual blanching conditions for specific vegetables.

ECONOMICS

The cost of blanching using a new system such as microwave or hot-gas is a critical factor in any decision to replace currently used equipment. Therefore, a serious attempt was made in this study to gather information on which to base cost estimates of commercial scale equipment for microwave, hot-gas, steam and hot-water blanching. The information on capital costs, cooling water usage, make-up water volumes, power consumption and space requirement were obtained by suppliers or potential suppliers of commercial scale equipment. The operating costs were estimated from power usage and public utility fee schedules as well as general estimates of cost of wastewater treatment. The cost estimate was designed to represent an unspecified commodity being blanched in a unit of approximately 5 tons/hr capacity. The uncertainties of estimation made the cost estimate useful only as a rough screening of economic practicability of a new blanching system before more extensive testing and collection of cost factors were considered.

SECTION V

EXPERIMENTAL RESULTS

BLANCHING

Asparagus - The green asparagus used in 1971 studies was obtained from Washington State in two spaced deliveries. The stalks were trimmed by hand to five-in. lengths (cutting off the butt ends). This asparagus was blanched in three of the four units; the hot-gas blancher was not completely installed while fresh canning asparagus was available in 1971. The results of the short duration blanching experiments with asparagus are tabulated in Appendix F and include the results of experiments with hot-gas blanching conducted in Stockton, California in 1972. The results of long duration blanching of asparagus are tabulated in Table 2.

Table 2 Long Term Blanching Runs for Green Asparagus

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Feed Time, Min	Residence Time, Sec	Temp, °F	Prod Yield, %	Perox Inact Slope
Raw	-	-	-	-	-	-	0.17
ASP-38	5 kw Microwave + Steam Injection	110	45	145	144	91	0.055
ASP-36	Steam	180	60	100	200	94	0.00
ASP-37	Hot-Water	120	60	90	180	104	.016
TLF-4	Hot-Gas	500	60	131	265	91	0.00 *

* The peroxidase inactivation slope for 1972 raw asparagus was 0.40.

Table 3 lists the wastewater volume and characteristics for green asparagus blanching in the four experimental units. The results of analysis of grab samples taken from the hot-water blancher are tabulated in Appendix G.

Table 3 Wastewater Volume and Characteristics for Green Asparagus Blanching

Run No.	Blanching Unit	Waste Water Vol , Gal.	COD, mg/l	SS, mg/l	pH
ASP-38	5 kw Micro-wave + Steam Injection	1.3	3500	44	6.8
ASP-36	Steam	4.3	2500	40	6.7
ASP-37	Hot-Water	100	100	1	7.7
TLF-4	Hot-Gas	0	No wastewater formed		

Green Peas - The green peas used for the blanching studies were Alaska variety freezer peas taken from the flume between the third stage washer and the hot water blancher at a commercial freezing plant. The peas had a temperature of 70 °F as they were loaded into a refrigerated truck for transport to the NCA Berkeley Laboratory. The peas in the lug boxes located in the center of a stack of boxes in the truck did not lose heat rapidly enough to avoid souring. The bulk of the soured peas were sorted out on receipt and only the better quality material used in the blanching experiments. The peas used were of sufficient quality to provide useful measurement of blanching effects except for organoleptic evaluation.

The results of the short duration experiments on blanching of green peas are tabulated in Appendix F.

The long term blanching experiments with green peas are summarized in Table 4.

Table 4 Long Term Blanching Runs for Green Peas

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Feed Time, Min	Residence Time, Sec	Temp, °F	Prod Yield, %	Perox Inact Slope
Raw	-	-	-	-	-	-	1.8
P-17	5 kw Microwave + Steam Injection	220	54	160(15)* 206(39)*	150	98	0.60
P-13	Hot-Gas	710	46	120	255	99	0.14
P-3	Steam	180	55	90	180	100	0.013
P-6	Hot-Water	210	58	90	185	99	0.043

* Numbers in parentheses indicate feed time in minutes at listed residence time

The wastewater volume and characteristics for blanching of green peas in four experimental units is tabulated in Table 5.

Table 5 Wastewater Volume and Characteristics for Green Pea Blanching

Run No.	Blanching Unit	Waste-Water Vol , Gal.	COD, mg/l	SS, mg/l	pH
P-17	5 kw Microwave + Steam Injection	4.25	54,300	630	4.2
P-13	Hot-Gas + Steam Injection	0.005	-	-	-
P-3	Steam	4.0	41,000	3,700	4.6
P-6	Hot-Water	100	3,920	170	4.4

Green Beans - The green beans used in the short-duration blanching runs were obtained at a cannery in Eugene, Oregon and transported to Berkeley in an air conditioned station wagon. The beans were pole beans which had been snipped and size-graded. The results of the short-duration blanching runs for green beans are tabulated in Appendix F.

The green beans used for the longer-duration runs were obtained in Junction City, Oregon and transported to Berkeley in two air-condition station wagons. The beans were cut bush beans of Number 3 sieve size. The results for the long-term blanching experiments with green beans are tabulated in Table 6.

Table 6 Long Term Blanching Runs for Cut Green Beans

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Feed Time, Min	Residence Time, Sec	Temp, °F	Prod Yield%	Perox Inact Slope
Raw	-	-	-	-	-	-	4.8
BN-26	5kw Microwave + Steam Injection	120	50	206	130	92	0.53
BN-25	Hot-Gas + Steam Injection	340	60	333	250	82	0.06
BN-27	Steam	190	56	217	190	94	0.07
BN-28	Hot Water	120	60	291	190	98	0.06

The wastewater volumes and characteristics from long-term blanching of green beans are tabulated in Table 7.

Table 7 Wastewater Volume and Characteristics for Cut Green Bean Blanching

Run No.	Blanching Unit	Wastewater Vol, Gal.	COD, mg/l	SS, mg/l	pH
BN-26	5 kw Microwave + Steam Injection	2.4	1,500	46	6.5
BN-25	Hot-Gas + Steam Injection	0.043	900	88	7.7
BN-27	Steam	4.25	5,400	100	6.1
BN-28	Hot Water	100	330	8	7.3

Corn - The corn used in the blanching experiments was obtained in Eugene, Oregon on September 8, 1971. The corn was shipped to Berkeley in the husks. Commercial-scale corn husking and cutting equipment was loaned to NCA by the Green Giant Company from their plant in Belvidere, Illinois.

Corn was husked and a portion cut for blanching as cut kernels. In the initial run of unwashed cut kernels through the hot-gas blancher, about one fifth of the feed weight (95 lb) stuck on the wire mesh conveyor belt and caramelization of the starchy liquid adhering to the corn kernels took place. The product recovered from the belt weighted 77 lb (80% recover). The conveyor belt was cleaned by hand brushing of the moving belt (at maximum speed setting) with steam injection into the unit and a continuous water spray on the belt at the product discharge end. The cleaning took 27 minutes and used 34 gal of fresh water. The cleaning wastewater composite had a COD of 18,000 mg/l and a SS of 3,200 mg/l.

The lack of successful blanching of unwashed cut kernel corn with the hot-gas blancher made it necessary (for comparative purposes) to run all four blanching units using corn-on-cob. The blanched corn-on-cob was cut for preparation of canned whole kernel corn samples.

The results of short-duration blanching runs on corn-on-cob in the four experimental units are tabulated in Appendix F.

The results of longer-term blanching of corn-on-cob in the four experimental blanchers are tabulated in Table 8.

Table 8 Long Term Blanching Runs for Corn-on-Cob

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Feed Time, Min	Residence Time, Sec	Temp, °F	Prod Yield, %	Perox Inact Slope
Raw	-	-	-	-	-	-	0.110
CN-14	5 kw Microwave + Steam Injection	160	60	224	130	95	0.067
CN-10	Hot-Gas + Steam Injection	360	60	330	260	98	0.022
CN-15	Steam	220	60	435	195	98	0.040
CN-12	Hot-Water	230	47	437	190	96	0.067

The wastewater volumes and characteristics for longer-term blanching of corn-on-cob are tabulated in Table 9.

Table 9 Wastewater Volume and Characteristics for Corn-on-Cob Blanching

Run No.	Blanching Unit	Wastewater Vol, Gal.	COD, mg/l	SS, mg/l	pH
CN-14	5 kw Microwave + Steam Injection	0.75	4,300	73	6.3
CN-10	Hot-Gas + Steam Injection	0.0024	500	1	6.8
CN-15	Steam	3.12	9.400	90	6.4
CN-12	Hot-Water	110	460	4	7.7

Red Beets - A mixture of small and medium sized, washed, red beets were obtained in Eugene, Oregon on September 15, 1971 and brought to Berkeley. The results of short-duration blanching runs with beets in the four experimental units are tabulated in Appendix F. The results of long term blanching of beets are tabulated in Table 10.

Table 10 Long Term Blanching Runs for Red Beets

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Feed Time, Min	Residence Time, Sec	Temp, °F	Prod Yield, %	Perox Inact Slope
Raw	-	-	-	-	-	-	1.14
BT-10	5 kw Microwave + Steam Injection	240	30	93	130	100.	0.105
BT-7	Hot-Gas + Steam Injection	157	60	625	250	94	0.045
BT-8	Steam	142	53	660	195	96	0.038
BT-11	Hot-Water	150	60	510	198	99	0.075

The wastewater volumes and characteristics for longer-term blanching of beets are tabulated in Table 11.

Table 11 Wastewater Volume and Characteristics for Red Beet Blanching

Run No.	Blanching Unit	Wastewater Vol., Gal.	COD, mg/l	SS, mg/l	pH
BT-10	5 kw Microwave + Steam Injection	0.50	320	47	5.3
BT-7	Hot Gas + Steam Injection	0.007	1,500	10	7.0

Table 11 Cont'd

Run No.	Blanching Unit	Wastewater Vol., Gal.	COD, mg/l	SS, mg/l	pH
BT-8	Steam	4.75	7,200	420	5.0
BT-11	Hot-Water	100	370	14	7.10

Pumpkin - The pumpkins used in the blanching experiments were obtained near Gridley, California on October 19, 1971 and transported whole to the Berkeley Laboratory. The pumpkin was cut by hand into random-sized pieces (1 in. square up to 3 in. square) and the seeds removed.

The results of short-duration blanching runs for pumpkin are tabulated in Appendix F. The results from the longer-term blanching experiments with pumpkin pieces are tabulated in Table 12.

Table 12 Long Term Blanching Runs for Pumpkin Pieces

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Feed Time, Min	Residence Time, Sec	Temp, °F	Prod Yield, %	Perox Inact Slope
Raw	-	-	-	-	-	-	7.43
PM-13	5 kw Microwave + Steam Injection	130	60	390	140	94	1.22
PM-14	Hot-Gas + Steam Injection	130	60	625	250	86	0.079
PM-15	Steam	140	60	600	196	93	0.0057
PM-16	Hot-Water	120	60	510	210	94	0.013

The wastewater volumes and characteristics for longer-term blanching of pumpkin are tabulated in Table 13.

Table 13 Wastewater Volume and Characteristics for Pumpkin Piece Blanching

Run No.	Blanching Unit	Waste water Vol, Gal.	COD, mg/l	SS, mg/l	pH
PM-13	5 kw Microwave + Steam Injection	2.5	6,600	84	6.2
PM-14	Hot-Gas + Steam Injection	0.005	140	1	6.0
PM-15	Steam	4.5	10,400	48	6.1
PM-16	Hot-Water	110	640	10	7.2

Spinach - The spinach used in blanching experiments was obtained from Walla Walla, Washington. The spinach received at the cannery on October 27, 1971 was destoned and washed. The washed spinach was packed in plastic-lined lug boxes. Crushed ice was added to keep the product cool during the transport period. The spinach arrived in Berkeley in excellent condition on the evening of October 29, 1971.

The results of short-duration runs for microwave and hot-gas blanching of spinach are tabulated in Appendix F. No short-duration runs were made for steam and hot-water blanching because bench scale work, done earlier on samples of fresh market spinach, had established that adequate peroxidase inactivation for canning could be accomplished with a residence time of one minute at 180 ^{o}F.

The results for the long-term blanching experiments with whole leaf spinach are tabulated in Table 14.

Table 14 Long Term Blanching Runs for Spinach

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Feed Time, Min	Residence Time, Sec	Temp, °F	Prod Yield, %	Perox Inact Slope
Raw	-	-	-	-	-	-	0.72
SP-1	5 kw Microwave + Steam Injection	38	60	93	140	63	0.034
SP-2	Hot-Gas + Steam Injection	140	60	164	250	69	0.004
SP-3	Steam	230	26	79	180	91	0.0008
SP-4	Hot-Water	140	30	66	180	104	0.065

The wastewater volumes and characteristics for longer-term blanching of spinach with the four experimental units are tabulated in Table 15.

Table 15 Wastewater Volume and Characteristics for Spinach Blanching

Run No.	Blanching Unit	Waste-Water Vol, Gal.	COD, mg/l	SS, mg/l	pH
SP-1	5 kw Microwave + Steam Injection	0.63	280	37	5.6
SP-2	Hot-Gas + Steam Injection	0.003	990	1	6.9
SP-3	Steam	6.4	4700	210	6.1
SP-4	Hot Water	100	220	35	6.6

PRODUCT EVALUATION

The samples of canned vegetables prepared from the blanched material from each of the four units were stored at ambient temperature in the NCA Berkeley Laboratory for six months before any quality examination was made. The storage period was used to allow any slow chemical reactions due to inadequate blanching to show up as deteriorated product quality. Also, the storage period would allow time for any internal corrosion to occur due to inadequate blanching.

Taste - The canned samples of green asparagus, green beans, corn, beets and pumpkin (as pies) were presented to a laboratory taste panel. The results of the taste panel evaluation are tabulated in Table 16. It was not possible to get a taste panel results for green peas (raw product souring) or spinach (low vacuum due to excessive holding time of hot brine filled cans before closing and retorting).

Table 16 Taste Panel Evaluation of Canned Samples After Storage for Six Months

	Ranking Totals */Number of Judgements			
Commodity / Panel	1	2	3	4
Asparagus				
Microwave	32/11	46/16	55/16	51/16
Steam	26/11	34/16	38/16	31/16
Hot-Water	20/11	49/16	41/16	39/16
Commercial**	31/11	31/16	26/16	39/16
Green Beans				
Microwave	49/16	44/16	43/16	48/16
Hot-Gas	40/16	39/16	42/16	35/16
Steam	37/16	37/16	43/16	40/16
Hot-Water	34/16	34/16	32/16	37/16

Table 16 Cont'd

Commodity	Panel	Ranking Totals */Number of Judgements 1	2	3	4
Corn					
Microwave		26/16	24/15	28/16	28/16
Hot-Gas		51/16	41/15	40/16	42/16
Steam		38/16	31/15	34/16	39/16
Hot-Water		44/16	55/15	52/16	50/16
Beets					
Microwave		31/14	28/16	44/16	40/16
Hot-Gas		42/14	41/16	31/16	36/16
Steam		37/14	47/16	39/16	44/16
Hot-Water		30/14	44/16	40/16	40/16
Pumpkin (As Pies)					
Microwave		41/15	48/16	35/13	41/15
Hot-Gas		28/15	37/16	29/13	31/15
Steam		28/15	39/16	28/13	43/15
Hot-Water		43/15	38/16	38/13	34/15

* The ranking totals are sums of individual rankings with the best flavor given the lowest number.

** Sample purchased at a store to complete the set of four samples since hot-gas blanching of asparagus was not done at the time of the preparation of the other three samples.

Grading - Canned samples of green beans, whole kernel corn, whole beets, pumpkin and spinach prepared with microwave, hot-gas, steam and hot-water blanching were quality graded by inspectors from the USDA. The total scores from the grading are tabulated in Table 17 and the copies of the actual scoring sheets are in Appendix H. The higher the score number the higher the quality of the sample being scored.

Table 17 Quality Scores for USDA Grading of Canned Vegetables

Commodity	Total Score *
Green Beans	
Microwave	76
Hot-Gas	64
Steam	62
Hot-Water	72
Whole Kernel Corn	
Microwave	71
Hot-Gas	75
Steam	68
Hot-Water	82
Whole Beets	
Microwave	83
Hot-Gas	79
Steam	80
Hot-Water	80
Pumpkin	
Microwave	78
Hot-Gas	78
Steam	85
Hot-Water	84

Table 17 Cont'd

Commodity	Total Score *
Spinach	
Microwave	0**
Hot-Gas	0**
Steam	0**
Hot-Water	0**

* Higher the score the better the product quality
** All spinach samples scored 0 due to excessive stem material

Headspace Gases - The results of analysis of headspace gases in canned samples of vegetables are tabulated in Table 18.

Table 18 Headspace Gas Analysis of Canned Vegetables Stored Six Months

Commodity	Blanching Unit	Headspace Volume, ml	Percent N_2	CO_2	H_2*	Argon $+O_2$
Asparagus	Microwave	15.4	84	7.2	6.2	2.6
	Steam	10.8	94	3.5	0.0	2.5
	Hot-Water	8.6	86	3.7	6.3	4.0
Green Beans	Microwave	28.8	93	4.8	0.2	2.0
	Hot-Gas	29.1	89	5.5	3.6	1.9
	Steam	28.7	93	4.6	0.3	2.1
	Hot-Water	24.4	91	5.0	2.0	2.0

Table 18 Cont'd

Commodity	Blanching Unit	Headspace Volume, ml	Percent N_2	CO_2	H_2*	Argon $+O_2$
Spinach	Microwave	-	89	10.4	0.0	0.6
	Hot-Gas	-	87	10.5	0.3	2.2
	Steam	-	92	6.4	0.0	1.6
	Hot-Water	-	86	11.2	0.6	2.2
Beets	Microwave	21.0	74	5.7	18.3	2.0
	Hot-Gas	24.8	91	7.3	0.4	1.3
	Steam	17.8	93	3.9	0.0	3.1
	Hot-Water	26.5	88	5.2	4.6	2.2
Pumpkin	Microwave	21.4	90	6.6	1.4	2.0
	Hot-Gas	27.0	86	8.6	4.1	1.3
	Steam	15.3	90	7.9	0.0	2.1
	Hot-Water	21.1	91	6.6	0.3	2.1
Green Peas	Microwave	30.1	93	4.4	0.0	2.6
	Hot-Gas	28.8	88	4.0	0.9	7.1
	Steam	31.9	90	3.6	2.9	3.5
	Hot-Water	29.2	92	3.7	0.3	4.0

Table 18 Cont'd

Commodity	Blanching Unit	Headspace Volume, ml	Percent N_2	CO_2	H_2*	Argon $+0_2$
Corn	Microwave	42.9	91	3.9	0.0	5.1
	Hot-Gas	36.0	88	7.3	0.3	4.4
	Steam	38.5	92	5.8	0.3	.1.9
	Hot-Water	37.5	92	5.9	0.0	2.1

* Determined by difference

Internal Can Corrosion - The results of estimation of the extent of internal corrosion of cans used to store thermally processed vegetables are tabulated in Table 19.

Table 19 Estimation of Extent of Internal Corrosion of Cans Used to Store Vegetables for Six Months at 65 - 85 ^{o}F

Commodity	Average Extent of Corrosion*
Asparagus	
Microwave	2
Steam	2
Hot-Water	2
Commercial	3
Green Beans	
Microwave	1
Hot-Gas	1
Steam	1
Hot-Water	1

Table 19 Cont'd

Commodity	Average Extent of Corrosion*
Beets	
Microwave	1
Hot-Gas	1
Steam	1
Hot-Water	1
Green Peas	
Microwave	2
Hot-Gas	2
Steam	2
Hot-Water	2
Corn	
Microwave	2
Hot-Gas	1
Steam	1
Hot-Water	1
Spinach	
Microwave	1
Hot-Gas	3
Steam	2
Hot-Water	2
Pumpkin	
Microwave	3
Hot-Gas	2
Steam	2
Hot-Water	2

*4 = severe; 3 = moderate; 2 = slight; 1 = no corrosion

Vitamin and Mineral Content - The average values for vitamin content of raw, blanched and canned samples of vegetables are tabulated in Table 20. Individual results for vitamin content and related standard deviations are tabulated in Appendix I. The average values for mineral content of raw and blanched samples of vegetables are tabulated in Table 21. Individual results for mineral content and standard deviations are tabulated in Appendix J.

Table 20 Vitamin Content of Raw, Blanched, and Canned Vegetables
Average Values in mg/100g

Commodity	Vitamin	Raw	Blanched Samples				Canned and Stored (Six Months) Samples			
			Microwave	Hot-Gas	Steam	Hot-Water	Microwave	Hot-Gas	Steam	Hot-Water
Asparagus	B_1	.22	*	.18	*	*	.053	-	.051	.057
	B_2	.22	.19	.19	.20	.20	.096	-	.090	.11
	C	19.	14.	11.	22.	18.	3.8	-	3.6	3.6
	Niacin	1.55	1.82	.73	1.46	1.65	.64	-	.76	.72
Green Peas	B_1	.07	.10	.14	.07	.06	.10	.11	.10	.089
	B_2	.17	.17	.17	.13	.15	.075	.082	.067	.068
	B_6	*	.24	.27	.32	.22	.14	.15	.10	.11
	C	**	**	**	**	**	2.6	4.7	3.9	3.1
	Niacin	*	1.93	2.03	1.95	1.72	1.1	1.2	.92	.91
Green Beans	B_1	*	*	*	*	*	.29	.40	.30	.29
	B_2	.13	.13	.12	.12	.12	.054	.066	.060	.056
	B_6	.056	.058	.037	.053	.057	.051	.054	.048	.059
	Niacin	.49	.64	.73	.56	.57	.36	.38	.35	.32
Corn	B_1	*	*	*	*	*	.025	.026	.026	.023
	B_2	.12	.11	.12	.11	.11	.079	.079	.077	.071
	B_6	*	*	*	*	*	.070	.077	.072	.073
	Niacin	1.41	2.23	2.06	2.18	1.91	1.08	1.12	1.07	.95
Beets	B_2	.061	.054	.068	.045	.041	.016	.013	.014	.023
	C	6.9	6.8	7.5	5.6	7.9	4.1	5.0	4.1	4.8
	Niacin	.24	.21	.26	.20	.20	.08	.09	.11	.09
Pumpkin	A	5.78	5.05	4.06	7.91	4.66	3.74	3.09	2.98	5.22
	Niacin	.49	.38	.57	.26	.32	.41	.44	.33	.28
Spinach	A	2.30	4.02	4.21	3.63	3.74	1.57	2.25	3.26	4.46
	B_2	.072	.15	.13	.10	.073	.11	.096	.081	.089
	C	**	**	**	**	**				

* Enzyme used gave poor results, sample used up in other analyses
** Samples lost during storage period

Table 21 Mineral Content of Raw and Blanched Vegetables
Average Values in mg/100g

Commodity	Mineral	Raw	Blanched Sample: Microwave	Hot-Gas	Steam	Hot-Water
Asparagus	Ca	21.2	22.1	19.3	22.0	20.2
	Mg	15.7	15.5	15.2	14.4	16.4
	P	67.0	77.0	61.5	70.0	69.5
Green Peas	Ca	*	14.2	14.[illegible]	13.0	14.2
	Mg	*	28.5	29.1	27.6	28.3
	P	*	104.	114.	101.	98.
	Fe	*	1.03	1.06	.99	1.04
Green Beans	Ca	40.0	45.8	52.0	39.2	40.6
	Mg	27.0	29.3	33.1	26.5	27.1
	P	36.0	40.0	48.0	36.0	38.4
	Fe	1.25	1.32	1.54	1.24	1.19
Corn	P	83.0	91.3	79.0	90.0	*
Beets	P	22.7	26.0	26.6	23.4	21.2
Pumpkin	Ca	9.2	8.8	13.5	10.7	9.2
	Mg	6.7	12.9	10.9	9.6	7.2
	P	11.6	21.5	13.9	14.2	9.7
Spinach	Ca	62.2	86.0	68.0	65.0	50.5
	Mg	63.5	89.5	65.0	65.5	49.0
	P	20.0	50.2	42.5	42.5	31.4
	Fe	3.1	3.4	3.2	3.3	3.1

* Sample lost

ECONOMICS

The detailed cost estimate for vegetable blanching with the four systems used in this study are tabulated in Appendix K. A summary of the cost estimates is tabulated in Table 22.

Table 22 Summary of Cost Estimates for Four Commercial Scale Blanching Systems*

	Cost/Ton Blanched, Dollars			
	Fixed Cost**	Operating***	Waste Management	Total
Hot-Gas	2.19	1.20	.00	3.39
Microwave	14.72	3.72	.03	18.47
Hot-Water	1.26	0.87	.23	2.36
Steam	1.11	0.95	.15	2.21

* Based on 5 tons/hr, 1800 hr season

** Capital costs include: amortization, interest, space rent, taxes, insurance, maintenance

*** Operating costs include: electric power, steam consumption, gas consumption, water use, part replacement when applicable, and labor.

The assumptions used in making the cost estimates were the following:

Blancher capacity -- Five tons/hr.

Annual operating period -- Five week season for each of three commodities. Six day work week with blanchers operating 20 hr. day. Therefore, the total operating period annually would be 3 x 5 x 6 x 20 or 1800 hr.

First cost -- The purchase price of commercial scale blanchers supplied by manufacturers of food processing equipment. The purchase price of the microwave blancher included the cost of a cooling tower for removing heat from the water used to cool the power tubes.

Amortization -- Defined as the capital recovery factor (crf) and assuming 7 percent interest, 5 year amortization period and no salvage value.

Space rent -- This was set at $12.00/sq ft/year. One thousand sq ft was provided for the microwave unit due to the space required for the wave generating unit in addition to the blancher space requirement. Five hundred sq ft was provided for the other three blanching units. Boiler space requirements were ignored since all four units require steam.

Taxes -- These were set at $5.00/$100.00 of assessed value based on 25 percent of market value.

Insurance -- This was set at 0.2 percent of assessed value/year.

Maintenance -- This can only be roughly estimated since this factor varies with the complexity of the equipment and with the care in which it is operated. The estimates used ranged from 1 to 2.5 percent of first cost/year.

Electrical power -- A rate of $.035/kwh was used for the hot-gas, steam and hot-water blanchers and a rate of $.0125 for the microwave blancher due to its much larger power requirements. All rates were obtained from Pacific Gas and Electric Company General Service Schedule No. A-1.

Steam consumption -- The steam required by the microwave blancher was the figure provided by the Varian Corporation and that required for the hot-gas blancher roughly estimated since no steam flow meter was used with the experimental unit.

For the hot-water and steam blanchers, steam consumption was calculated from the following formula (17):

$$S = \frac{5.5\ C\ (T_2 - T_1)}{E}$$

where:

S = steam requirement (brake horse power)

C = process rate (tons/hr)

T_2 = steam temperature ($^{\circ}F$)

T_1 = temperature of incoming product ($^{\circ}F$)

E = efficiency

It should be noted that the above formula yields only a estimated steam consumption. The blancher efficiencies were arbitrarily selected to represent mean efficiencies over a range of 30-90 percent with the consideration that hot-water blanchers are more efficient than steam blanchers. Blancher efficiency is dependent on characteristics such as wall insulation and venting and thus is difficult to estimate.

Natural gas -- The cost was taken from the Pacific Gas and Electric Company Schedule referred to above.

Water -- The figure of $ .10/100 cu ft was obtained from the Varian Corporation as the cost of make-up water for the cooling tower losses. The estimate of 10 gpm of make-up water for the hot-water blancher was provided by the FMC Corporation.

Waste disposal -- The figure of $.05/lb for BOD and SS removal was obtained from a report prepared by NCA for the U.S. Environmental Protection Agency (2). Amounts of waste were determined from the studies described above and represent averages of runs involving seven vegetables. The values used only approximate those expected from commercial blanching operations.

Labor -- Figures of $ 4/hr plus $ .40/hr benefits were used to calculate costs. Due to the complexity of the microwave and hot-gas units (primarily the control requirements) it was estimated that each unit would require one worker. For the steam and hot-water blanchers provision was made for a half-time worker.

SECTION VI

DISCUSSION

The objectives of this study were to test the feasibility of one new (hot-gas) and one partially investigated (microwave) blanching system as replacements for the currently used hot-water and steam blanching systems. The overall feasibility was determined by examining, in sequence, the factors of peroxidase inactivation, blanched product appearance and texture, wastewater generation and characteristics, product quality and cost estimates. The feasibility of the proposed replacement systems could have been eliminated at any of the stages of the testing program. For example, at the start of the study there was no assurance that hot-gas blanching would reduce peroxidase levels in a given vegetable using practical residence times and operating temperatures.

The fact that the blanching units used in this study were simulators of possible commercial scale equipment must be emphasized. While every effort was made to operate the simulators as closely as possible to commercial conditions, it should be obvious that the results obtained are only approximations of an actual commercial result. Also, after a few initial experiments with microwave and hot-gas blanching it was apparent that steam injection was required to get the most effective use of energy inputs and to avoid dehydration of the raw vegetable. Therefore, the microwave and hot-gas blanching systems were not "pure" systems but operationally were "mixed" systems more properly termed microwave-steam or hot-gas-steam, respectively. For purposes of brevity, the simple designations of microwave and hot-gas are used in this report but it should be understood that steam was injected in the majority of experimental runs.

The first consideration in the text of feasibility of microwave and hot-gas blanching was the degree of peroxidase inactivation which could be achieved at reasonable residence times. The extent of peroxidase inactivation found in samples collected near the mid-point of the long duration runs are tabulated in Table 23 with the residence times shown in parentheses.

Table 23 Comparison of Peroxidase Inactivation and Residence Times for Blanching of Vegetables

Commodity	Percent Peroxidase Inactivation at (Minutes of Residence Time) Microwave	Hot-Gas	Steam	Hot-Water
Asparagus	67 (2.4)	100 (2.2)	100 (1.7)	90 (1.5)
Peas	66 (3.0)	92 (2.0)	99 (1.5)	98 (1.5)
Beans	89 (3.4)	99 (5.6)	99 (3.6)	99 (4.8)
Corn	39 (3.7)	80 (5.5)	64 (7.2)	39 (7.3)
Beets	91 (1.5)	96 (10.4)	97 (11.0)	93 (8.5)
Pumpkin	84 (6.5)	99 (10.4)	100 (10.0)	100 (8.5)
Spinach	95 (1.5)	99 (2.7)	100 (1.3)	91 (1.1)

The target peroxidase inactivation value selected for this study was 90 percent. This value, which represents a residual peroxidase content of 10 percent, was chosen since such as extent of inactivation would be satisfactory for a canned final product. Essentially complete peroxidase inactivation would be required for frozen preservation. Many of the short duration runs tabulated in Appendix F lists blanching conditions which produce 100 percent peroxidase inactivation and would be useful for blanching of vegetables to be preserved by freezing.

The extent of peroxidase inactivation resulting from microwave blanching showed the greatest variability from vegetable to vegetable. The average extent of peroxidase inactivation was lower for microwave blanching than for the other three blanching methods. This observation of variability of extent of peroxidase inactivation suggests that the energy produced flucuates during different periods of operation at the same settings of the dials on the control panel of the microwave blancher. The microwave blancher appeared to be more effective with the large piece size vegetables such as beets and pumpkin than with smaller sized vegetables such as peas.

The hot-gas blancher was the most reliable of the two newer blanching systems in reducing peroxidase levels at residence times similar to those used for steam and hot-water blanching. The only low value found for hot-gas blanching (80 percent for corn-on-cob) was still considerably higher than the value found for steam and hot-water at somewhat longer residence times. It can be concluded that hot-gas blanching has the potential of reducing peroxidase levels to useful degrees at practical residence times.

The appearance, softening, wilting and wrinkling of vegetables blanched by the hot-gas unit, with the exception of cut kernel corn, were satisfactory and no different from the changes caused by steam or hot-water blanching. There were no observations made on hot-gas blanched samples which indicated a potential difficulty in a subsequent operation such as peeling, cutting, blending or filling into containers.

One of the most important parts of this study was the measurement of wastewater volume and characteristics. The primary motivation for examining the feasibility of potential replacement blanching systems was the need for reduction of wastewater generation during vegetable blanching. The volume of wastewater generated for each of the seven vegetables during blanching with the four units are tabulated in Table 24. Inspection of the data in Table 24 leads to the conclusions that wastewater volume is about the same for microwave and steam blanching and both of these are significantly smaller than the volume from hot-water blanching. The most striking conclusion is the very large reduction in wastewater volume from hot-gas blanching compared even to the volume from steam blanching. It can be concluded that hot-gas blanching is truly a low volume liquid effluent blanching system.

Table 24 Wastewater Generation During Vegetable Blanching

Vegetable	Microwave	Hot-Gas	Steam	Hot-Water
	Wastewater Volume, Gal/Ton			
Asparagus	32	0	48	1700
Peas	43	0.018	48	1000
Beans	48	0.25	48	1700
Corn	9.4	0.013	28	1200
Beets	8.3	0.087	77	1300
Pumpkin	84	0.076	64	1800
Spinach	33	0.043	130	2900

The low volume of liquid effluent product by hot-gas blanching results in high concentrations of COD and SS in the wastewater. Therefore, it is important to compare the pounds of COD and SS produced during blanching since these values are related to the treatment required to avoid potential water pollution. Table 25 tabulates the pounds of COD and SS produced per ton of vegetable blanched with each of the four units. It can be seen from the data in Table 25 that for all practical purposes the hot-gas blancher produces insignificant amounts of COD and SS. This result was the most significant finding in the study.

Table 25 Pounds of COD and SS Produced During Vegetable Blanching

	Lb/Ton Blanched							
	Microwave		Hot-Gas*		Steam		Hot-Water	
Commodity	COD	SS	COD	SS	COD	SS	COD	SS
Asparagus	.9	.012	0	0	10	.016	1.4	.014
Peas	20	.22	-	-	16	1.5	32	1.4
Beans	.60	.018	.002	0	2.2	.04	4.7	.11
Corn	.34	.0057	0	0	2.2	.021	4.6	.04
Beets	.02	.0033	.001	0	4.6	.27	4.0	.15
Pumpkin	2.1	.027	0	0	5.6	.026	9.6	.15
Spinach	.077	.010	0	0	5.1	.23	5.3	.85

* Any value less than 0.001 was considered equivalent to zero

The above discussion has concluded that hot-gas blanching is effective in reducing enzyme activity of vegetables without significant generation of liquid waste. The next factor to consider in determining overall feasibility was product quality. The results for taste, grading, headspace gases, internal can corrosion and vitamin and mineral content were subjected to analysis of variance. In none of the five product quality categories was there a statistically significant difference due to the blanching treatment received. This result means that hot-gas blanching produces a final product at least equivalent in quality to products produced using microwave, steam and hot-water blanching.

The final stage of determination of overall feasibility is cost estimation. The cost estimation is based on a summation of individual estimates and its usefulness is related to the validity of the individual estimates. The major source of possible error in the cost estimates occurs in the estimate of first cost for the hot-gas blancher. The figure of $50,000 which was used in the cost estimate was obtained from a potential supplier of hot-gas blanching equipment and was based on a limited engineering design consideration. The experimental hot-gas blancher used in this study, which had an average capacity of 500 lb/hr, cost $20,500. It did not seem realistic to use a simple scale-up factor of 20 to estimate the cost of a 5 ton/hr hot-gas blancher ($410,000) since much of the cost was due to custom design and fabrication. In-plant studies with the hot-gas blancher, after completing the pilot-plant study, have suggested that the large blower does not accomplish movement of the vegetable pieces. It is possible that a simplified hot-gas blancher, which depends on convection currents to expose the vegetable pieces to hot combustion products, would be less costly. Therefore, this amount of $50,000 was used as the first cost for a commercial scale hot-gas blancher.

The amounts tabulated in Table 22 for cost of blanching show hot-gas blanching, while more costly, is not prohibitively expensive. In view of the uncertainty of the cost estimate, further investigation of hot-gas blanching is desirable to develop more accurate cost factors.

The most significantly different cost factor is comparing hot-gas blanching with steam and hot-water blanching is in waste management. Hot-gas blanching may be more attractive economically in the next few years as waste treatment costs increase as the national goal of zero discharge of pollutants by 1985 is approached. The very small volume of liquid effluent produced during hot-gas blanching make it an excellent choice as part of closed loop technology.

The cost of waste treatment is going to increase as the percent removal of BOD and SS increases. For those processors discharging into municipal treatment systems, an increase in treatment level will increase the surcharges paid by the industrial discharger. It is likely that waste management costs will increase substantially; this will make hot-gas blanching economically more competitive with steam or hot-water blanching.

SECTION VII

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Process, Case No. WQO - 43 - 72 (G),

February 22, 1973.

SECTION X

GLOSSARY

Acceptance -- (1) An experience or feature of experience, characterized by a positive (approach in a pleasant) attitude. (2) Actual utilization (purchase, eating). May be measured by preferences or liking for specific food item.

Analysis of Variance -- A method of determining the significance of differences in a group of averages of experimental observations by partitioning of the total sum of squares and degrees of freedom, and estimation of the standard deviation of the population by two or more methods and a comparison of these estimates.

Amortization -- (1) Gradual reduction, redemption, or liquidation of the balance of an account according to a specified schedule of times and amounts. (2) Provision for the extinguishment of a debt by means of a sinking fund.

Appearance -- The visual properties of a food, including size, shape, color, and conformation.

BOD -- Abbreviation for biochemical oxygen demand. The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions.

COD -- Abbreviation for chemical oxygen demand. A measure of the oxygen-consuming capacity of inorganic and organic matter present in water or wastewater.

Blanching -- Heating a food to a temperature high enough to inactivate enzymes present and to remove undesirable occluded gases and contaminants.

Coding -- Assignment of symbols, usually letters and/or numbers, to test samples so that they may be presented to a subject without identification.

Consumer -- An individual who obtains or uses a commodity.

Cooling tower -- A vertical structure with internal baffles to break up flowing water so that it is cooled by upward-flowing air and by evaporation of water.

Enzyme -- A catalyst produced by living cells which is protein in nature.

Flavor -- An attribute of foods, beverages, and seasonings resulting from stimulation of the sense ends that are grouped together at the entrance of the alimentary and respiratory tracts - especially odor and taste.

Fixed charge -- A charge that cannot be escaped, shifted, or altered, such as interest, rent, taxes and amortization.

Make-up water -- Water added to circulating water in a system to replace water lost by evaporation, leakage, or blowdown.

Panel -- A group of people (observers, subjects, judges) comprising a test population which has been specially selected or designated in some manner.

Peroxidase -- A class of enzymes which catalyze the reaction of molecular oxygen with a substrate to produce a peroxide link in the altered molecule.

Protein -- Any of the complex nitrogeneous compounds formed in living organisms which consist of amino acids bound together by peptide linkages.

Quality -- The composite of the characteristics that differentiate among individual units of the product and have significance in determining the degree of acceptability of the unit by the user.

Ranking -- A procedure of arranging food products in order according to some criterion and assigning consecutive integers (ranks) correspond ing to the order.

Sample -- A specimen or aliquot presented for inspection.

Score -- A value assigned to a specific response made to a test item.

Suspended Solids (SS) -- Solids that either float on the surface of, or are in suspension in, water, wastewater or other liquids.

Taste -- One of the senses usually limited to four qualities: saline, sweet, sour and bitter.

Vapor pressure -- The pressure exerted by a material in the gaseous state when confined in a space of fixed volume.

SECTION X
APPENDICES

Appendix A

MICROWAVE BLANCHING UNIT SPECIFICATIONS

Length	20 ft
Width	2 ft
Microwave frequency	2450 $\pm$ 50 MHz
Microwave power (2-2.5 kw power packs)	5 kw
Entrance and exit port size	4 in. high x 12 in. wide
Belt	1/4 in. mesh, coated fiberglass
Belt speed	0-20' per min, reversible
Cavity material	Stainless steel
Finish	28 exterior; 4B
Power requirements:	220V: 3-phase; 60 Hz
Conveyor only	1 kVA
Air heaters only	30 kVA
Each power pack	5 kVA
Air supply	Adjustable 200-600 cfm
Air temperature controllable to 250°F	
Water requirements (each power pack)	1.5 gpm @ 20 psig/min
Steam	40 psig

Appendix B

HOT-GAS BLANCHING UNIT SPECIFICATIONS

Length:	16.5 ft
Width:	6.5 ft
Conveyor:	Stainless steel belt in two levels each with flights, 3 in. high and 12 in. apart
Conveyor width:	12 in.
Conveyor drive:	Variable speed motor with 10 fold speed range
Heater:	Natural gas fired burners Rated at 125,000 Btu/hr
Blower:	3800 standard cu ft/min
Air Temperature:	250°F Maximum
Product Capacity:	500 lb/hr

Appendix C

STEAM AND HOT-WATER BLANCHING UNIT SPECIFICATIONS

Length:	8.5 ft.
Width:	18.5 in.
Belt Width:	15.25 in.
Material of Construction:	18 - 8 (304) stainless steel
Bearings:	Bronze brushed with grease fittings
Conveyor (chain)	No. 40, extended pitch
Shaft diameter:	1 in.
Drapes:	B-N standard type, 16 GA. mesh 3/16 in. openings with 2.5 in. high flights at 6 in. spacing
Drive:	4.9 - 49 rpm, U.S. Varidrive RT. angle, 0.5 hp, 3 phase, 60 cycle
Belt speed:	4-40 fpm
Steam coil test pressure:	225 psig

Appendix D

TASTE PANEL SCORING SHEET

Please taste and rank samples in order of flavor preference. Take completed scoring sheets and used sample tray to cutting room.

CODE	FLAVOR RANKING 1 = Best; 4 Worst
L	
M	
N	
O	

Date____________________ Tasters' Initials__________

Appendix E HEADSPACE GAS ANALYSIS METHOD

Cans are opened under water, beneath a funnel connected to either a 50 or 100 ml burette to collect and read the volume of headspace gas.

The burette can be modified by a glass blower by cutting off stop cock and placing it on top, above the zero mark. A small side arm is made to take the sampling septum (Kontes silicone rubber stopper No. K77-4200). The space between the stop cock and the zero mark, including the side arm should be as small as practically possible (measure the volume). Now, below the 50 ml graduation mark, put a side arm, which will be connected to the leveling bulb by means of rubber tubing. The large funnel is also connected to the burette through rubber tubing.

The procedure is as follows:

1. Clamp tubing.

2. Open burette at stop-cock and draw water into the burette through funnel, with the help of vacuum.

3. When full, close stop cock and clamp tubing.

4. Remove clamp and fill leveling bulb and tubing with water, squeeze tubing with fingers to make absolutely certain that no air bubbles are trapped in it.

5. Place can to be sampled into the water and remove all visible air droplets clinging to its surface.

6. Place can underneath the funnel and punch a hole in it with a church key. Usually the can is put on its side and the hole punched so that the gas will not escape immediately, but will do so when the can is rotated under the funnel.

7. Once all of the gas in the can has been collected, adjust the liquid level in the burette to that of the leveling bulb and read the volume of gas (add the volume above the zero mark).

9. Raise the leveling bulb above the level of the gas in the burette; this will give a slight positive pressure inside the burette. Insert the syringe through the septum, pump it two or three times, and withdraw the sample.

10. Inject into the chromatograph.

Standards

For N_2 and 0_2, air is used and figure on a proportion of eight parts N_2 to two parts 0_2.

For CO_2 and H_2, buy a mixture of 50:50 from Mathieson. Close off the valve on the $CO_2 + H_2$ tank and apply vacuum. Close off vacuum and open up tank valve, repeat this two or three times and then take the sample through the septum.

Chromatographic conditions are as follows:

Column 1: Fourteen inches x 1/4" O.D., Cu; Silica Gel 30/60 mesh.

Column 2: Transfer column, 20 ft x 1/8", Cu; This column connects the outlet of column 1 to the inlet of column 3.

Column 3: 12 ft x 1/4" molecular sieve 5A, 30/60 mesh.

Oven temperature - This will vary according to the condition of the columns. Start at around 100°C, and increase gradually, if analysis takes too long.

Detector temperature - 200°C

Injector temperature - 150°C

Carrier gas - He; It will be necessary to experiment with the flow rate until the best rate according to conditions is found.

The first peak to show up is made up of all the gases except CO_2, which appears very shortly after that. Once the CO_2 peak has completely gone through, as indicated by the recording pen coming back to the base line, switch polarity and H_2, O_2 and N_2 will appear in that order.

Using He as a carrier, a plot of concentration vs peak height should give a straight line for each of CO_2, N_2 and O_2. This is not usually true of H_2, which as its concentration relative to He increases will give a peak with an inverted tip. Usually H_2 is determined by difference. Add up the percentage of the three remaining gases and compute the difference.

It seems that what has been called O_2 in the headspace gas for several years is probably argon. The conditions used cannot separate argon and oxygen. To detect O_2, it would be necessary to use argon as a carrier gas (in which case a peak shows up) it would indicate the presence of oxygen, as argon would not respond.

Appendix F SHORT DURATION BLANCHING RUNS

Green Asparagus

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp, ^oF	Peroxidase Inactivation Slope
Raw-1971	-	-	-	-	0.192
ASP-7	5 kw Microwave	49	673	183	Overblanched
ASP-8	"	240	84	183	0.193
ASP-9	"	300	84	151	0.210
ASP-10	"	160	160	151	0.160
ASP-11	"	105	281	151	0.033
ASP-12	4 kw Microwave	100	398	210	0.010
ASP-13	"	225	130	210	0.285*
ASP-14	3 kw Microwave	225	130	210	0.300*
ASP-15	"	66	281	210	0.135
ASP-16	"	86	206	210	0.175
ASP-17	"	113	160	210	0.175
ASP-32	5 kw Microwave + Steam Injection	257	84	144	0.233
ASP-33	"	168	160	144	0.055
ASP-34	"	168	104	144	0.165
ASP-35	"	N.R.	130	144	0.080
ASP-1	Steam	323	135	212	Overblanched
ASP-2	"	331	100	212	0.008
ASP-18	"	400	79	200	0.005
ASP-19	"	267	100	200	0.003
ASP-20	"	268	134	200	0.00
ASP-3	Hot Water	120	227	180	0.007
ASP-5	"	172	147	190	0.004
ASP-21	"	278	90	180	0.04

Appendix F Cont'd

Green Asparagus Cont'd

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp, ^{o}F	Peroxidase Inactivation Slope
ASP-22	"	288	66	180	0.04
ASP-23	"	343	52	180	0.10
ASP-27		267	90	190	0.007
Raw-1972	-	-	-	-	0.4
ASPS-1	Hot-Gas + Steam Injection	400	165	240	0.0002
ASPS-2	"	600	106	260	0.0002
ASPS-3	"	600	105	200	0.0002
ASPS-4	"	450	145	240	0.0002
ASPS-5	"	500	131	250	0.0002
ASPS-6	"	430	150	250	0.0002

N.R. Not Recorded

* Higher values due to lower moisture content of sample.

Appendix F Cont'd

Green Peas

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp °F	Peroxidase Inactivation Slope
Raw	-	-	-	-	1.75
P-14	5 kw Microwave + Steam Injection	138	160	150	0.58
P-16	"	139	130	150	0.51
P-15	0 kw	167	160	150	1.80
P-7	Hot-Gas	133	720	225	0.01
P-8	Hot-Gas + Steam Injection	300	120	220	0.03
P-9	"	300	120	205	0.08
P-10	"	343	120	226	0.18
P-11	"	369	120	237	Overblanched
P-12	"	1200	120	250	0.14
P-1	Steam	N.R.	62	180	0.85
P-2	"	150	90	180	0.02
P-4	Hot-Water	274	62	180	0.93
P-5	Hot-Water	192	90	185	0.07

Appendix F Cont'd

Green Beans

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp, ^{o}F	Peroxidase Inactivation Slope
Raw 3 Sieve Size	-	-	-	-	Optical Density Greater than 2
BN-6	5 kw Microwave + Steam Injection	85 3 Sieve Size	281	146	0.41
BN-7	"	111 3 Sieve Size	206	130	0.44
BN-8	"	108 2 Sieve Size	206	130	0.42
BN-9	"	129 2 Sieve Size	180	112	0.53
BN-10	"	120 1 Sieve Size	130	98	0.81
BN-1	Hot-Gas + Steam Injection	170 3 Sieve	183	220	1.0
BN-2	"	200 3 Sieve Size	183	250	0.19
BN-3	"	109 3 Sieve Size	303	250	0.03
BN-4	"	150 3 Sieve Size	233	250	0.03
BN-5	"	200 3 Sieve Size	183	250	0.06
BN-11	"	203 2 Sieve Size	136	250	0.12
BN-12	"	300 1 Sieve Size	103	250	0.38

Appendix F Cont'd

Green Beans

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp °F	Peroxidase Inactivation Slope
BN-13	Steam	180 3 Sieve Size	217	180	0.25
BN-14	"	172 3 Sieve Size	217	190	0.10
BN-15	"	172 3 Sieve Size	90	190	0.12
BN-16	"	124 2 Sieve Size	217	190	0.18
BN-17	Steam	138 1 Sieve Size	90	190	0.20
BN-18	"	129 1 Sieve Size	217	190	0.16
BN-19	Hot-Water	146 3 Sieve Size	291	190	0.04
BN-20	"	154 3 Sieve Size	182	"	0.05
BN-21	"	142 2 Sieve Size	182	"	0.08
BN-22	"	120 2 Sieve Size	227	"	0.09
BN-23	"	112 1 Sieve Size	182	"	0.08
BN-24		100 1 Sieve Size	227	"	0.11

Corn-on-Cob

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp, ^{o}F	Peroxidase Inactivation Slope
Raw	-	-	-	-	0.110
CN-4	5 kw Microwave + Steam Injection	82	422	142	Overblanched
CN-5	"	100	224	140	0.008
CN-6	"	194	133	140	0.008
CN-1	Hot-Gas + Steam Injection	400	240	255	0.028
CN-2	"	320	330	255	0.034
CN-3	"	202	390	260	0.005
CN-7	Steam	201	561	195	Overblanched
CN-8	"	172	658	195	Overblanched
CN-9	"	266	435	195	0.020
CN-11	Hot-Water	187	373	190	0.04

Red Beets

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp, ^{o}F	Peroxidase Inactivation Slope
Raw	-	-	-	-	1.140
BT-4	5 kw Microwave + Steam Injection	85	224	130	Overblanched
BT-5	"	239	93	130	0.145
BT-6	"	305	53	130	0.210
BT-1	Hot-Gas + Steam Injection	69	1100	258	Overblanched

APPENDIX F Cont'd

Red Beets Cont'd

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp, ^{o}F	Peroxidase Inactivation Slope
BT-2	"	131	625	258	0.073
BT-3	"	170	390	250	0.100
BT-9	Steam	155	330	198	0.04
	Hot-Water*	-	480	200	0.04

*Earlier runs with fresh market beets

Pumpkin Pieces

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp, ^{o}F	Peroxidase Inactivation Slope
Raw	-	-	-	-	7.43
PM-1	5 kw Microwave + Steam Injection	50	680	80	0.64
PM-2	"	50	680	140	0.13
PM-3	"	150	390	140	0.10
PM-10	Hot-Gas + Steam Injection	200	330	235-250	1.8
PM-11	"	140	390	250-265	0.10
PM-12	Steam Injection	65	1100	250-265	0.33
PM-4	Steam	150	766	193	0.002
PM-5	"	224	560	194	0.047
PM-6	"	256	340	196	0.11
PM-7	Hot-Water	400	227	190	7.0
PM-8	"	200	510	192	1.7
PM-9	"	200	510	209	0.033

APPENDIX F Cont'd

Spinach

Run No.	Blanching Unit	Feed Rate, Lb/Hr	Residence Time, Sec	Temp, °F	Peroxidase Inactivation Slope
Raw	-	-	-	-	-
SP-1A	5 kw Microwave + Steam Injection	17	224	140	-
SP-1B	"	16	133	140	Overblanched
SP-2A	Hot-Gas + Steam Injection	N.R.	330	250	Dried
SP-2B	"	N.R.	183	250	Overblanched

APPENDIX G

CHARACTERISTICS OF GRAB SAMPLES FROM HOT-WATER BLANCHER

Commodity	Sampling Time, Min	COD, mg/l	SS, mg/l	pH
Asparagus	15	51	1	7.7
	30	72	0	7.7
	45	100	0	8.1
	60	130	0	7.4
Green Peas	15	1,760	113	4.6
	30	3,900	176	4.6
	45	4,550	180	4.7
Green Beans	15	150	1	7.5
	30	200	4	7.3
	45	370	3	7.1
	60	490	10	6.9
Beets	15	160		
	30	250		
	45	400		
	60	620		
Pumpkin	15	220	5	7.4
	30	450	15	7.2
	45	780	15	7.0
	60	910	16	7.0
Spinach	15	190	22	6.4
	30	260	29	6.4

APPENDIX H

USDA SCORING SHEETS FOR QUALITY GRADING OF CANNED VEGETABLES

SHEET 1 OF 1 SHEETS

FORM FV-356-6 (9-15-69)

U.S. DEPARTMENT OF AGRICULTURE
CONSUMER AND MARKETING SERVICE

SCORE SHEET FOR CANNED ASPARAGUS
(EFFECTIVE MAY 7, 1963)

CONT. NO.	
P.O. NO.	CERT. FORM
REF. NO.	CERT. NO.

NAME AND ADDRESS OF APPLICANT: NATIONAL CANNERS ASSOCIATION, BERKELEY, CALIFORNIA

NO., SIZE AND KIND OF CONTAINER: 300

LABEL: U/L

	STEAM		MICRO		HOT-LATOR	
CONTAINER MARK OR IDENTIFICATION — CANS/~~GLASS~~	ASPGC 71 SB		ASPGC 71 MB		ASPGC 71 HB	
NET WEIGHT (OUNCES)	14.4		14.5		14.2	
VACUUM (INCHES)	17		18		16	
DRAINED WEIGHT (OUNCES)	8.1		7.7		7.2	
TYPE: GREEN						
STYLE: CUT SPEARS						
SIZE (SPEARS, TIPS, POINTS): N/A						
COUNT (SPEARS, TIPS, POINTS): N/A						
LENGTH OF CUT: 1½"						
~~PERCENT OF~~ HEADS (COUNT/TOTAL)	23/72		19/57		24/73	
I. LIQUOR — 10 — (A) 9-10, (C) 7-8, (SStd) 0-6*	7		8		8	
II. COLOR — 20 — (A) 17-20, (C) 14-16, (SStd) 0-13*	18		18		17	
III. DEFECTS — 30 — (A) 25-30, (C) 21-24*, (SStd) 0-20*	5 UNBRKN 5		4 UNBRKN 5		3 UNBRKN 5	
IV. CHARACTER — 40 — (A) 34-40, (C) 28-33*, (SStd) 0-27*	3 TOUGH 36		3 TOUGH 36		6 TOUGH 34	
TOTAL SCORE — 100	66		67		64	
FLAVOR (A, C* OR SStd*)	A		A	BOTTOM A (HIGH SALT LEVEL)	A	BOTTOM A [illegible] LEVEL
GRADE	SSTD		SSTD		SSTD	

CHARGE ON CERTIFICATE	
FEE	
EXPENSES	
TOTAL	

PRINCIPAL REASONS FOR DEGRADING PRODUCT

OFFICIAL INSPECTOR: B. [illegible] (signature)

DATE: 2/14/72

*Limiting rule.

APPENDIX H Cont'd

FORM FV-384-6 (7-23-61)

SHEET OF SHEETS

U. S. DEPARTMENT OF AGRICULTURE
CONSUMER AND MARKETING SERVICE

SCORE SHEET FOR
CANNED GREEN AND WAX BEANS
(Effective July 23, 1961)

CONT. NO.	
P.O. NO.	CERT. FORM
REF. NO.	CERT. NO.

NAME AND ADDRESS OF APPLICANT: National Canners Association, 1950 Sixth Street, Berkeley California 94710

NO., SIZE AND KIND OF CONTAINER: 303 cans (enameled line) Contact Dr Jack W Ralls 415-843-9762

LABEL: Inked on can side

		510.2	520.7	521.5	526.8					AVERAGE
CONTAINER MARK OR IDENTIFICATION	PRIMARY CONTAINERS	BEAAP	BEA P	BEAAP	BEAAP					
	CASES	Hot H2S 71 HH	Hot water 71 AB	Steam 71 SH	Microwave 71 MB					
NET WEIGHT (Ounces)		15.7	16.1	16.1	16.3					
VACUUM (Inches)		10	12	12	12					
DRAINED WEIGHT (Ounces) (8.7)		8.8	7.2	8.4	8.4					
TYPE (Green) Wax (Round) or Flat)										
STYLE		Cut				Cans Not well filled				
SIEVE SIZE		Mostly 3 sieve								
LENGTH OF CUT (If cut)		1/2 to 1 1/2 inch cuts								

FACTORS		SCORE POINTS	510.2	520.7	521.5	526.8	Remarks
CLEARNESS OF LIQUOR	10	(A) 9-10 (B) 8 (C) 7 (SStd) 0-6 *	Slack filled 7	Slack filled 9	Slack filled 6	Slack filled 8	All samples appear badly over blanched - Much flocculant material
COLOR	15	(A) 14-15 (B) 12-13 (C) 10-11* (SStd) 0-9 *	9	11	9	13	all samples have bad oxidation
ABSENCE OF DEFECTS	35	(A) 31-35 (B) 28-30** (C) 25-27* (SStd) 0-24*	23	23	22	24	All samples darkends. Beans appear to be oxidized
CHARACTER	40	(A) 36-40 (B) 32-35* (C) 28-31* (SStd) 0-27*	Heavy Slough Mushy 25	Soft 29	Heavy Slough ~~Soft~~ Mushy 25	Soft 31	All samples very soft. 2 spls Mushy.
TOTAL SCORE	100		64	72	62	76	
FLAVOR AND ODOR (Normal or Off)							
GRADE			SSt	SSt	SSt	SSt	

CHARGE ON CERTIFICATE	
FEE	
EXPENSES	
TOTAL	

REMARKS: Product appears as if it was held & oxidized & wilted prior to processing

OFFICIAL INSPECTOR: Leo M. LeBoire

DATE: 2-18-72

*Limiting rule. **Partial limiting rule.

SHEET 1 OF 1 SHEETS

FORM FV-364-18 (6-14-57)

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE

SCORE SHEET FOR CANNED WHOLE KERNEL (WHOLE GRAIN) CORN

(EFFECTIVE JULY 30, 1952)

CONT. NO.

P.O. NO. | CERT. FORM

REF. NO. | CERT. NO.

NAME AND ADDRESS OF APPLICANT: National Canners Assoc. Berkeley, Calif

NO., SIZE AND KIND OF CONTAINER: 303 metal tins

LABEL: sample (541.4) (541.6) (541.1) (540.5)

CONTAINER MARK OR IDENTIFICATION						
Embossed CANS/GLASS		CORN	CORN	CORN	CORN	
CASES		HOT-BAG 71 AB	HOT-WATER 71 HB	MICROWAVE 71 MB	STEAM 71 SB	
NET WEIGHT (OUNCES)		17.0	17.0	17.0	16.9	
VACUUM (INCHES)		9	9	7	10	
DRAINED WEIGHT (OUNCES)		11.0	11.2	10.5	11.1	
COLOR (WHITE OR YELLOW)						Broad grain
FACTORS	SCORE POINTS	8/c bag	8/c bag	8/c bag	8/c bag	
I. COLOR	10 (A) 9-10 (B) 8 (C) 6-7 x (SStd) 0-5 *	7	6	6	4	1st sample has slight grey cast due to pulled kernels otherwise kernel color Grade A. 2nd & 3rd samples dull grey cast. 4th sample definitely off color has grey sediment
II. CUT	10 (A) 9-10 (B) 8 (C) 6-7 x (SStd) 0-5 *	7	8	7	6	1st, 3rd & 4th samples have many pulled kernels. 2nd sample cut too deep - but not as many pulled kernels
III. ABSENCE OF DEFECTS	20 (A) 18-20 (B) 16-17* (C) 14-15* (SStd) 0-13*	pulled k. 10	14	pulled K high silk 10	Sludge Pulled Kernels 9	All samples have pulled kernels. 4th sample - has sludge, cob material & pulled kernels
IV. TENDERNESS AND MATURITY	40 (A) 36-40 (B) 32-35* (C) 30-31* (SStd) 0-29*	34	36	33	34	If product cleaned up product would
V. FLAVOR	20 (A) 18-20 (B) 16-17 (C) 14-15* (SStd) 0-13*	16	18	15	16	be easier to grade. Grade really doesn't mean anything at this time because of
TOTAL SCORE	100	75	82	71	68	cob silk & pulled kernels.
GRADE		SSd	C	SSd	SSd	

AVERAGE

sediment discolored + badly

CHARGE ON CERTIFICATE

FEE

EXPENSES

TOTAL

PRINCIPAL REASONS FOR DEGRADING PRODUCT: 1st Grade, Average Score, Dr. Wt.

OFFICIAL INSPECTOR: R.H. Bovio

DATE: 2/25/72

* Limiting rule. x Partial limiting rule.

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APPENDIX H Cont'd

SHEET 1 OF 1 SHEETS

Form FV-364-10 (4-22-57)

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE

SCORE SHEET FOR CANNED BEETS
(EFFECTIVE FEBRUARY 4, 1955)

CONT. NO.

P.O. NO. | CERT. FORM

REF. NO. | CERT. NO.

NAME AND ADDRESS OF APPLICANT: National Canners Assoc. Berkeley Calif.

NO., SIZE AND KIND OF CONTAINER: 303 metal cans

LABEL: sample (5294) (539.6) (540.3) (540.?)

CONTAINER MARK OR IDENTIFICATION		CANS/GLASS	BEET	BEET	BEET	BEET										AVERAGE
		CASES	71 AB HOT WATER	71 HB HOT AIR	71 MB MICRO	71 SB STEAM										
NET WEIGHT (OUNCES)			16.9	16.9	16.9	16.9										
VACUUM (INCHES)			13	10	7	6										
DRAINED WEIGHT (OUNCES)			7.8	8.	7.8	8.-										
STYLE		whole														
COUNT (WHOLE)			7	6	5	6										
SIZE OF SLICES (DIAMETER)																
SIZE OF CUT (DICED OR JULIENNE) (IN.)																
FACTORS		SCORE POINTS														
I. COLOR	25	(A) 21-25 (C) 18-20* (SStd) 0-17*	20	20	23	20		Samples 1, [illegible] have [illegible]								
II. UNIFORMITY OF SIZE AND SHAPE	15	(A) 12-15 (C) 8-11 (SStd) 0-7x	8	8	8	8		samples not size graded								
III. ABSENCE OF DEFECTS	30	(A) 26-30 (C) 22-25* (SStd) 0-21*	24	23	24	24		Considerable unpeeled [illegible], some beets have black external discoloration								
IV. TEXTURE	30	(A) 26-30 (C) 22-25* (SStd) 0-21*	28	28	28	28		Good texture								
TOTAL SCORE	100		80	79	83	80										
NORMAL FLAVOR AND ODOR			OK													
GRADE			B	—	—	—										

CHARGE ON CERTIFICATE	
FEE	
EXPENSES	
TOTAL	

PRINCIPAL REASONS FOR DEGRADING PRODUCT: Lot Grade / Average Score / Dr. Wt.

OFFICIAL INSPECTOR: [signature]

DATE: 2-25-72

* Limiting rule. x Partial limiting rule.

APPENDIX H Contd

U.S. DEPARTMENT OF AGRICULTURE
CONSUMER AND MARKETING SERVICE

SCORE SHEET FOR

CANNED PUMPKIN and CANNED SQUASH
(EFFECTIVE MARCH 9, 1956)

CONT. NO.

P.O. NO. | CERT. FORM

REF. NO. | CERT. NO.

NAME AND ADDRESS OF APPLICANT
NATIONAL CANNERS ASSOCIATION
BERKELEY, CALIFORNIA

NO., SIZE AND KIND OF CONTAINER: 300

LABEL: u/L

CONTAINER MARK OR IDENTIFICATION													
CANS			PUMKN 71 AB		PUMKN 71 1B		PUMKN 71 SB		PUMKN 71 HB				AVERAGE
CASES			HOT-GRS		MICRO		STEAM		HOT-WATER				
SAMPLE NO.			1		2		3		4				
NET WEIGHT (OUNCES)			16.3		16.3		16.3		16.3				
VACUUM (INCHES)			13		10		11		14				
FACTORS	SCORE POINTS												
COLOR	20	(A) 18-20 (C) 14-17* (SStd) 0-13*	18		18		20		19				
CONSISTENCY	30	(A) 25-30 (C) 21-24* (SStd) 0-20*	FREE LIQUOR 15		FREE LIQUOR 15		FREE LIQUOR 20		FREE LIQUOR 20				
FINISH	20	(A) 17-20 (C) 14-16 (SStd) 0-13*	17		17		17		17				
DEFECTS	30	(A) 25-30 (C) 21-24* (SStd) 0-20*	28		28		28		28				
TOTAL SCORE	100		78		78		85		84				
NORMAL FLAVOR			N		N		N		N				
GRADE			SSTD		SSTD		SSTD		SSTD				

CHARGE ON CERTIFICATE	
FEE	
EXPENSES	
TOTAL	

REMARKS
SUBSTANDARD ACCOUNT CONSISTENCY
(FREE LIQUOR SEPARATION)
SAMPLES 1 AND 2 SLIGHTLY DARKER IN COLOR THAN
SAMPLES 3 AND 4.

OFFICIAL INSPECTOR
B. Eleanor

DATE
2/23/72

* Limiting Rule.

APPENDIX H Cont'd

FORM FV-384-156 (3-30-70)

U. S. DEPARTMENT OF AGRICULTURE
CONSUMER AND MARKETING SERVICE

DEFECT TALLY SHEET FOR CANNED SPINACH
(EFFECTIVE MARCH 30, 1970)

NAME AND ADDRESS OF APPLICANT: NATIONAL CANNERS ASSOC BERKELEY, CALIF.

GRADE: SAMPLE NOS. 1 AND 4 SUBSTANDARD ACCOUNT EXCESSIVE STEM MATERIAL SAMPLE NO 2 GRADE B ACCOUNT STEM MATERIAL SAMPLE NO 3 GRADE A

STYLE: ☐ WHOLE LEAF ☐ CUT LEAF OR SLICED ☒ CHOPPED

DATE: 2/23/72

INSPECTOR: [signature]

NO., SIZE, AND KIND OF CONTAINER: 300

LABEL: U/L HOT-GAS MICRO STEAM HOT WATER

	1	2	3	4	5	6	7	8	9	10	11	12	
CONTAINER OR IDENTIFICATION — CANS/~~GLASS~~	SPIN 71 AB		SPIN 71 MB		SPIN 71 SB		SPIN 71 HB						
~~CASES NO~~ SAMPLE	1		2		3		4						
NET WEIGHT (OUNCES)	16.6		16.1		16.6		16.1						
VACUUM (INCHES)	4		4		5		6						
DRAINED WEIGHT (OUNCES)	10.6		9.8		9.9		9.8						
SAMPLE UNIT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	SAMPLE AVERAGE
QUALITY FACTORS	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Severe	Min. Maj. Sev.
COLOR													
CHARACTER													
DAMAGE													
HARMLESS EXTRANEOUS MATERIAL — PLANT — Green fine													
Green, coarse													
Other													
Seed head													
Root crown													
Root stub													
OTHER THAN PLANT													
TOTAL (EACH CLASS)													
CUMULATIVE TOTAL (ALL CLASSES)	0		0		0		0						0
STEM MATERIAL 25% (A) 30% (B)	33.9		27.6		19.2		32.7						
FLAVOR AND ODOR — Good	X		X		X		X						
FLAVOR AND ODOR — Objectionable													

Appendix I Vitamin Content of Raw, Blanched, and Canned Vegetables, Values in mg/100 g wet weight (Standard Deviation)

Commodity	Vitamin	Raw	Blanched Samples: Microwave	Blanched Samples: Hot-Gas	Blanched Samples: Steam	Blanched Samples: Hot-Water	Canned and Stored (Six Months) Samples: Microwave	Canned and Stored (Six Months) Samples: Hot-Gas	Canned and Stored (Six Months) Samples: Steam	Canned and Stored (Six Months) Samples: Hot-Water
Asparagus	B_1	.22	*	.178	*	*	.049	-	.059	.057
		(.0)		.177			.057		.043	.056
				(.001)			(.01)		(.011)	(.001)
	B_2	.218	.162	.183	.226	.198	.104	-	.092	.110
		.230	.202	.189	.190	.208	.087		.087	.104
		(.008)	.212	(.004)	.172		(.012)		(.004)	(.004)
			(.03)		(.027)	(.007)				
	C	18.7	13.4	11.1	22.5	16.7	3.79	-	3.69	3.55
		19.0	13.4	10.4	22.0	19.8	3.79	-	3.55	3.69
		18.3	14.2	10.4	22.2	16.7	(.0)		(.10)	(.10)
		19.2	14.9	10.6	21.4	17.1				
		18.1	14.1	(.4)	(.5)	(1.5)				
		(.5)	(.6)							
	Niacin	1.56	1.80	.70	1.40	1.60	.70	-	.80	.71
		1.58	1.85	.75	1.53	1.70	.60		.76	.75
		1.52	1.80	.71	1.40	1.60	.62		.80	.70
		(.03)	(.03)	.76	(.08)	1.68	.65		.73	.70
				(.03)		(.05)	(.04)		(.03)	(.02)
Green Peas	B_1	.07	.10	.14	.07	.06	.099	.110	.102	.089
		(.0)	(.0)	(.0)	(.0)	(.0)	.100	.108	.103	.089
							(.001)	(.001)	(.001)	(.0)
	B_2	.168	.177	.176	.129	.157	.075	.083	.064	.065
		.173	.170	.170	.125	.143	.075	.081	.070	.072
		(.004)	(.005)	.004	.003	.010	(.0)	(.001)	(.005)	(.005)
	B_6	*	.24	.27	.32	.22	.109	.154	.096	.098
							.154	.154	.122	114
							.142	140	.096	.109
							(.025)	(.008)	(.015)	(.008)

Appendix I Cont'd Vitamin Content of Raw, Blanched, and Canned Vegetables, Values in mg/100 g wet weight (Standard Deviation)

			Blanched Samples				Canned and Stored (Six Months) Samples			
Commodity	Vitamin	Raw	Microwave	Hot-Gas	Steam	Hot-Water	Microwave	Hot-Gas	Steam	Hot-Water
Green Beans	B_1	*	*	*	*	*	.290	.386	.290	.295
							.280	.411	.300	.290
							(.007)	(.02)	(.007)	(.004)
	B_2	.12	.14	.12	.12	.11	.055	.069	.058	.053
		.12	.12	.12	.12	.12	.053	.062	.061	.058
		.14	.14	.12	.12	.12	(.001)	(.005)	(.002)	(.004)
		.13	(.01)	(.00)	(.00)	(.01)				
		(.01)								
	B_6	.051	.077	.038	.069	.077	.049	.049	.046	.063
		.053	.064	.036	.055	.062	.051	.051	.054	.050
		.064	.046	.036	.046	.050	.053	.063	.044	.064
		(.007)	(.016)	.039	.041	.040	(.002)	(.008)	(.005)	(.008)
				(.002)	(.012)	(.016)				
	Niacin	.43	.59	.80	.70	.65	.35	.43	.40	.35
		.55	.65	.79	.55	.61	.36	.36	.35	.33
		.48	.70	.60	.52	.51	.38	.38	.35	.33
		.50	(.06)	(.11)	.47	.50	.33	.39	.33	.30
		(.06)			(.10)	(.07)	(.02)	.32	.33	.31
								(.04)	(.03)	(.02)
Corn	B_1	*	*	*	*	*	.025	.026	.025	.022
							.024	.025	.026	.021
							(.001)	(.001)	(.001)	(.001)
	B_2	.120	.102	.112	.106	.119				
		.109	.115	.120	.105	.107	.078	.077	.079	.071
		(.008)	(.009)	.006	(.001)	(.008)	.080	.082	.074	.070
							(.001)	(.004)	(.004)	(.001)
	B_6						.064	.082	.079	.069
							.082	.078	.061	.076
		.18	.23	.16	.19	.19	.065	.071	.076	(.005)
							(.008)	(.006)	(.003)	

Appendix I Cont'd Vitamin Content of Raw, Blanched, and Canned Vegetables, Values in mg/100 g wet weight (Standard Deviation)

Commodity	Vitamin	Raw	Blanched Samples				Canned and Stored (Six Months) Samples			
			Microwave	Hot-Gas	Steam	Hot-Water	Microwave	Hot-Gas	Steam	Hot-Water
Corn	Niacin	1.42	2.25	2.20	2.25	1.97				
		1.35	2.25	2.00	2.13	1.70	.94	1.00	1.04	.90
		1.50	2.18	2.12	2.22	2.00	1.19	1.07	1.00	1.00
		1.36	(.04)	1.93	2.13	1.98	1.10	1.22	1.03	.94
		(.07)		(.12)	(.06)	(.14)	(.13)	1.20	1.19	1.00
								(.11)	(.09)	(.05)
Beets	B_2	.048	.049	.062	.035	.036	.015	.014	.015	.023
		.074	.059	.074	.054	.046	.016	.011	.013	.022
		(.013)	(.007)	(.008)	(.013)	(.007)	(.001)	(.002)	(.001)	(.001)
	C	6.9	6.8	7.5	5.6	7.9	4.1	5.0	4.1	4.8
	Niacin						.075	.093	.118	.093
		.250	.213	.263	.200	.200	.078	.094	.102	.088
		.231	.213	.256	.194	.200	.088	.092	.110	.092
		(.013)	(.00)	(.005)	(.004)	(.0)	.075	.083	.109	.083
							.006)	.005)	(.008)	(.005)
Pumpkin	A	5.78	5.05	4.06	7.91	4.66	3.74	3.09	2.98	5.22
		(.0)	(.0)	(.0)	(.0)	(.0)	(.0)	(.0)	(.0)	(.0)
	Niacin	.44	.38	.66	.32	.30	.37	.40	.28	.23
		.53	.34	.57	.25	.31	40	.45	.33	.29
		.52	.42	.53	.24	.33	.38	.42	.32	.27
		.47	.37	.53	.25	.35	.47	.49	.39	.32
		(.04)	(.03)	(.06)	(.04)	(.02)	(.05)	(.04)	(.05)	(.04)
Spinach	A	2.30	4.02	4.21	3.63	3.74	1.28	1.94	2.90	4.06
							1.87	2.57	3.62	4.87
							(.14)	(.14)	(.11)	(.13)
	B_2	.065	.156	.130	.094	.067	.107	.095	.079	.088
		.079	.133	.138	.101	.078	.109	.096	.084	.090
		(.01)	(.015)	(.006)	(.005)	(.008)	(.001)	(.001)	(.004)	(.001)
	C	*	*	*	*	*				

* Sample Lost

Appendix J Mineral Content of Raw and Blanched Vegetables, Values in mg/100 g wet weight (Standard Deviation)

Commodity	Mineral	Raw	Blanched Samples			
			Microwave	Hot-Gas	Steam	Hot-Water
Asparagus	Ca	20.9, 21.4 (.4)	22.1, 22.1 (.0)	19.2, 19.4 (.1)	21.9, 22.1 (.1)	19.8, 20.5 (.5)
	Mg	15.8, 15.6 (.1)	15.4, 15.6 (.1)	15.2, 15.2 (.0)	14.4, 14.4 (.0)	16.3, 16.4 (.1)
	P	68.0, 66.0 (1.4)	77.0, 77.0 (.0)	62.0, 61.0 (.7)	70.0, 70.0 (.0)	69.0, 70.0 (.7)
Peas	Ca	*	14.3, 14.0 (.2)	14.2, 14.6 (.3)	13.0, 13.0 (.0)	14.2, 14.1 (.1)
	Mg	*	28.3, 28.6 (.2)	28.4, 29.8 (1.0)	27.2, 28.0 (.6)	28.0, 28.6 (.4)
	P	*	106, 102 (3)	114, 114 (.0)	102, 100 (1)	96, 100 (3)
	Fe	*	1.00, 1.06 (.04)	1.05, 1.07 (.01)	.97, 1.00 (.02)	1.04, 1.03 (.01)
Beans	Ca	40.0, 40.0 (.0)	46.4, 45.2 (.8)	51.2, 52.8 (1.1)	40.0, 38.4 (1.1)	40.4, 40.8 (.3)
	Mg	28.0, 26.0 (1.4)	28.2, 30.4 (1.6)	33.0, 33.2 (.1)	26.6, 26.4 (.1)	26.6, 27.6 (.1)
	P	36.0, 36.0 (.0)	40.0, 40.0 (.0)	48.5, 47.5 (.7)	36.4, 35.6 (.6)	39.6, 37.2 (1.7)
Corn	P	87.0, 79.0 (5.7)	92.5, 90.0 (1.8)	82.0, 75.0 (4.9)	95.0, 85.0 (7.1)	*
Beets	P	21.6, 23.8 (1.6)	25.6, 26.4 (.6)	28.8, 24.4 (3.1)	22.0, 24.8 (2.0)	22.0, 20.4 (1.2)
Pumpkin	Ca	9.9, 8.5 (1.0)	11.3, 6.3 (3.5)	13.5, 13.5 (.0)	10.9, 10.5 (.3)	10.7, 7.7 (2.1)
	Mg	7.1, 6.3 (.6)	13.5, 12.3 (.8)	10.9, 10.9 (.0)	9.5, 9.7 (.1)	8.1, 6.3 (1.3)
	P	11.7, 11.4 (.2)	22.7, 20.2 (1.8)	14.2, 13.6 (.4)	15.2, 13.2 (1.4)	8.2, 11.2 (2.1)
Spinach	Ca	63.5, 66.4 (2.1)	84.0, 88.0 (2.8)	68.0, 68.0 (.0)	63.0, 67.0 (2.8)	45.5, 55.5 (7.1)
	Mg	67.3, 59.8 (5.3)	91.5, 87.3 (2.8)	65.5, 64.5 (.7)	67.5, 63.5 (2.8)	49.5, 48.5 (.7)
	P	17.2, 22.7 (3.9)	54.2, 46.2 (5.7)	42.7, 42.2 (.4)	42.2, 42.7 (.4)	33.7, 29.2 (3.2)

* Sample Lost

Aopendix K

COST ESTIMATES FOR COMMERCIAL SCALE BLANCHING

First Cost - 5 ton/hr Microwave blancher = $425, 000

Annual Fixed Costs

Amortization = FC x crf (7%, 5yrs = .24389)	=	$103, 655.
Space rent	=	12, 000.
Taxes	=	5, 310.
Insurance	=	850.
Maintenance (2.5% of FC/yr)	=	10, 625.
Total	=	$132, 440.
Hourly fixed cost (1800 hr yr)	=	73.58

Hourly Operating Costs

Electric power ($.0125/kwh) (210 kw)	=	2.63
Steam consumption ($1.00/1000 lb)	=	.80
Water consumption ($.10/100 cu ft)	=	.05
Klystron replacement (7 tubes @$9200, 6000 hr life)	=	10.73
Waste disposal ($.05/lb for BOD&SS)	=	.17
Labor (1 worker @ $4.40/hr)	=	4.40
Total	=	18.78

Total Hourly Cost

Fixed Cost=	73.58
Operating Cost=	18.78
Total =	92.36

Cost/lb vegetable blanched (10, 000 lb/hr)	=	.00924
Cost/ton vegetable blanched	=	18.47

Appendix K Cont'd

First Cost - 5 ton/hr Hot-gas blancher = $50, 000. 00

Annual Fixed Costs

Amortization= FC x crf (7%, 5 yrs = .24389)	=	$ 12, 195.
Space rent	=	6, 000.
Taxes	=	625.
Insurance	=	100.
Maintenance (1. 5% of FC/yr)	=	750.
Total	=	$ 19, 670.
Hourly fixed cost (1800 hr yr)	=	10. 93

Hourly Operating Costs

Electric power ($. 035/ kw)	=	. 61
Steam consumption ($ 1. 00/1000 lb)	=	. 10
Water consumption ($. 10/100 cu ft)	=	. 00
Gas consumption ($. 076/therm)	=	. 89
Waste disposal ($. 05/lb for BOD & SS)	=	. 00
Labor (1 worker @ $ 4. 40/hr)	=	4. 40
Total	=	$ 6. 00

Total Hourly Cost

Fixed Cost	=	10. 93
Operating Cost	=	6. 00
Total	=	16. 93
Cost/lb vegetable blanched (10, 000 lb/hr)	=	. 00169
Cost/ton vegetable blanched	=	$ 3. 39

Appendex K Cont'd

First Cost 5 ton/hr Steam blancher = $15.000.00

Annual Fixed Costs

Amortization= FC x crf (7%, 5 yrs = .24389)	=	$ 3,660.
Space rent		6,000.
Taxes		190.
Insurance		30.
Maintenance (1% of FC/yr)		150.
Total	=	$ 10,030.
Hourly fixed cost (1800 hr yr)	=	5.57

Hourly Operating Costs

Electric power ($ .035/kw)		.13
Steam consumption ($1.00/1000 lb)		2.41
Water consumption ($ .10/100 cu ft)		.00
Waste disposal ($ 0.05/lb for BOD & SS)		.76
Labor (1 Half-time worker @ $4.40/hr)		2.20
Total	=	$ 5.50

Total Hourly Cost

Fixed Cost	=	5.57
Operating Cost	=	5.50
Total	=	11.07
Cost/lb vegetable blanched (10,000 lb/hr)	=	.00111
Cost/ton vegetable blanched	=	2.21

Appendix K Cont'd

First Cost 5 ton/hr Hot-water blancher = $20,000.

Annual Fixed Costs

Amortization = FC x crf (7%, 5 yrs = .24389)	=	$ 4,880.
Space rent	=	6,000.
Taxes	=	250.
Insurance	=	40.
Maintenance (1% of FC/yr)	=	200.
Total	=	$ 11,370.
Hourly fixed cost (1800 hr yr)	=	6.32

Hourly Operating Costs

Electric power ($.035/kw)		.13
Steam consumption ($1.00/1000 lb)		1.92
Water consumption ($ .10/100 cu ft)		.08
Waste disposal ($ 0.05/lb for BOD & SS)		1.17
Labor (1 Half-time worker @ $4.40/hr)		2.20
Total	=	$ 5.50

Total Hourly Cost

Fixed Cost	=	6.32
Operating Cost	=	5.50
Total	=	11.82
Cost/lb vegetable blanched (10,000 lb/hr)	=	.00118
Cost/ton vegetable blanched	=	2.36

SELECTED WATER RESOURCES ABSTRACTS

INPUT TRANSACTION FORM

1. Report No.

2.

3. Accession No. **W**

4. Title Low Water Volume Enzyme Deactivation of Vegetables Before Preservation

5. Report Date 3-15-73

6.

7. Author(s)

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16. Abstract Four pilot-plant units were operated with asparagus, peas, corn, beans, beets, pumpkin and spinach to establish the potential for new blanching systems with low wastewater generation. The systems investigated were microwave, hot-gas, steam, and hot-water. Single runs of about one hour duration were made for each commodity with each blanching system. Wastewater volume was measured and samples were analyzed for COD, SS, and pH. The most striking result obtained was the small volume of steam condensate formed during hot-gas blanching. Canned samples of vegetable material from each blancher were prepared for quality evaluation after storage. Taste panels showed no significant flavor preference for samples from any individual blanching system. The system used had no significant effect on the vitamin and mineral retention of blanched or canned samples. The oxygen content of canned samples was lowest for hot-gas blanching compared to the other three systems. Estimates of the cost of blanching using commercial-scale units gave (dollars/ton blanched): microwave, 18.47; hot-gas, 3.39; steam, 2.21; and hot-water, 2.36.

17a. Descriptors

Blanching, vegetables, food processing, wastewater, reduced waste generation, microwave blanching, hot-gas blanching, steam blanching, hot-water blanching.

17b. Identifiers

Canning (food processing)

17c. COWRR Field & Group 05D

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