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Wastewater Abatement in Canning Vegetables by IQB Blanching

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WASTEWATER ABATEMENT IN CANNING VEGETABLES BY IQB BLANCHING

By

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ABSTRACT

This report presents the results of a study on the efficacy of a new blanching system, Individual Quick Blanch (IQB), as applied to vegetables prior to canning. Peas, corn, lima beans, green beans, potatoes, carrots and beets were adequately blanched by IQB. Compared to deep bed steam blanching or pipe blanching, IQB generally resulted in a significant reduction in effluent. Slight drying of the vegetables before IQB reduced effluent even more; however, product quality was adversely affected in most cases. It was demonstrated that the IQB process can significantly reduce effluent volume and BOD generation in the blanching operation while adequately fulfilling the objectives of blanching. Commercial application of IQB appears economically favorable.

This report was submitted in fulfillment of Project Number S-801484, by Daryl Lund, University of Wisconsin, under the partial sponsorship of the Environmental Protection Agency. Work was completed as of August 1973.

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ACKNOWLEDGMENTS

The cooperation and support of this project by the Oconomowoc Canning Company, Oconomowoc, Wisconsin, is acknowledged with sincere thanks. Personnel at the Sun Prairie and Waunakee Plants provided valuable assistance.

Partial financial support was provided by the Wisconsin Canners and Freezers Association and their contribution is gratefully acknowledged.

The IQB blanching unit was supplied by the Western Regional Research Laboratory, USDA, Berkeley, California. Obviously, without their support this project would not have been possible.

Thanks is also extended to the Hughes Company, Columbus, Wisconsin, for supplying some of the equipment required in this project.

A special thanks is extended to the Water Quality Laboratory, Wisconsin State Department of Natural Resources, Madison. This laboratory performed most of the water quality tests and thus provided the bulk of the raw data in this report.

Finally, acknowledgment is extended to personnel in the Department of Food Science who contributed to the successful completion of this project. Special thanks goes to the personnel of the Sensory Evaluation Laboratory and the taste panel members.

SECTION I

CONCLUSIONS

Conventional blanching operations result in the generation of high volume, high strength waste streams. The efficacy of a new blanching system, Individual Quick Blanching, was assessed with the objective of significantly reducing blanching effluent while maintaining product quality. IQB was applied to peas, corn, lima beans, green beans, potatoes, beets and carrots prior to canning.

IQB was found suitable for blanching vegetables prior to canning. Effluent generation was significantly reduced for peas, corn, lima beans and green beans compared to pipe blanching and deep bed steam blanching. Product quality tests indicated that IQB blanched, canned products were as good as pipe blanched, canned products. For potatoes, beets and carrots, IQB could be effectively used to inactivate peroxidase while minimizing inequity of heat treatment received by the surface and center of the product.

Slight drying of the product prior to IQB further reduced blancher effluents. However, generally canned product quality was adversely affected by this pretreatment.

SECTION II

RECOMMENDATIONS

This study was limited to a pilot plant evaluation of the individual quick blanching (IQB) system. It successfully demonstrated the potential of reducing canning plant effluent through the use of IQB. Peas, corn, lima beans, green beans, potatoes, carrots and beets were adequately blanched by IQB and product quality was in most cases as good as the conventionally blanched-canned product.

The next step for the development of IQB as a commercially viable blanching system would be the design and installation of a full size production unit. For that purpose, information contained in this report and in other published papers on IQB could be utilized for providing design parameters (loading rates and residence times).

If a private company or food equipment manufacturing company does not undertake the development of a commercial IQB unit, it is recommended that EPA seek a participant for a demonstration grant. Preferably a company with both freezing and canning facilities would undertake the project since the full potential of IQB as a blanching method could then be evaluated.

SECTION III

INTRODUCTION

GENERAL

Upgrading and maintenance of the environment is a major priority of government and private sector action. For the solution to the environmental problems, research and development activities are directed in three major areas: (1) identification of major pollution input from industrial and other sources, (2) development of alternative processes which eliminate or reduce effluent streams, and (3) development of effective, economically feasible utilization or treatment of waste material. In connection with these three activities, it was recognized that the food processing industry needed considerable effort. Although the food industry has advanced technologically in the conversion of raw agricultural products to consumer-acceptable products, little attention has been given to use of water and generation of high strength, large volume waste streams.

Waste management within food processing has several distinctive characteristics which do not allow the direct adaptation of practices used in other industries. First, processing of fresh agricultural plant material into consumer products is generally seasonal in nature resulting in an uneven demand for treatment facilities. This has created difficulties since it requires that the food plant either have its own treatment facilities which are used sporadically or that the food plant discharge its waste into municipal or other treatment facilities creating unusual peak demands. In either case, waste treatment problems are somewhat unique.

Second, the composite waste stream generated in the food processing plant is usually a high volume, relatively low strength stream. This results from the fact that water is required in nearly all unit operations in food processing and usually little effort is made to segregate streams based on organic strength.

BACKGROUND

Recent research activity designed to aid the food processing industry has centered on identifying those unit operations where high strength, high volume waste streams are generated and development of technology resulting in reduction of waste generation at those unit operations. Receiving considerable attention has been the food canning industry. In the conversion of raw agricultural product to shelf-stable canned products, waste streams of significant volume and strength are generated per unit of product. Analysis of the individual unit operations in canning indicates that the unit operation blanching (sometimes referred to as scalding) is a major source of effluent[1]. With identification of a major pollutional source, considerable research effort has been directed toward development of effective, economically feasible blanching operations.

The blanching operation fulfills several necessary functions including removal of tissue gases; inactivation or activation of enzymes, reduction of microbial load, cleansing of product, wilting of tissue to facilitate packing, and elevation of product temperature going into the retort. Currently, the food industry uses both hot water and steam for blanching. Both methods produce liquid wastes high in biochemical oxygen demand (BOD) and volume, and both result in loss of water soluble nutrients. Based on data reported by Weckel et al.[1] for two Wisconsin canning plants, a 90% reduction in blancher effluent would reduce total plant waste flow by 10 to 20% and, more significantly, reduce total plant BOD by 20 to 50%. The National Canners Association[2] estimated that if a new blanching method which reduced waste water strength by 50% were used for the seven vegetables processed in the largest tonnage, a total of approximately 32 million kg. (70 million pounds) of BOD and 18 million kg. (40 million pounds) of suspended solids would be eliminated from treatment plant loadings.

In the abatement of waste water flow and loss of solids from product in canning and freezing plants, a study was initiated in 1970 to design a blanching process which would have a waste water flow of only 10% of a commercial hot water blancher. The project was supported by the University of Wisconsin and the USDA, and was conducted by M. E. Lazar and D. B. Lund at the Western Marketing and Nutrition Research Division, USDA. The project resulted in a new concept of heating foods and the application to blanching was demonstrated[3,4]. The process, individual quick blanch (IQB), required further evaluation and, therefore, the Western Laboratory conducted a study utilizing IQB prior to freezing while the evaluation of IQB for blanching prior to canning was conducted in a Wisconsin canning plant.

The IQB process is a two-stage unit operation. In the first stage, the food piece is exposed to a heat source (condensing steam) for such duration that the mass-average temperature is in the range required for blanching (generally greater than 85 C [185 F]). The piece is then transferred to a second stage where the piece is held adiabatically until the thermal gradients have equilibrated to the mass average temperature and the objectives of blanching have been accomplished. The process results in less waste generation because: 1) steam condensation is limited to that required for heating the product into the blanching temperature range, 2) there is minimal opportunity for tissue damage and subsequent loss of cellular juices, and 3) there is no overheating of some of the tissue as in deep bed steam blanching which can result in tissue damage.

Lund[5] reported on the application of IQB to vegetables prior to canning. In that study, peas, corn, lima beans and green beans were blanched, canned, stored and objectively and subjectively evaluated. Evaluation of IQB, IQB with predrying and conventional pipe blanching showed that up to a 99% reduction in waste water generation could be achieved with IQB. The study also revealed that although predrying to greater than a 6% weight reduction would further reduce waste water generation, product quality was adversely affected.

SECTION IV

OBJECTIVES

The results in this report are a continuation and extension of the 1971 study. The present study was undertaken for several reasons: 1) to confirm the 1971 results with IQB, 2) to compare the IQB process to deep-bed steam blanching, 3) to apply the IQB process to different varieties of peas, 4) to extend the IQB process to the blanching of root crops such as potatoes, carrots and beets, and 5) to evaluate the heat-only stage of the IQB process as a blanching method. Objective 5) was included in the study since it had been observed that after blanching, and prior to can filling, vegetables are often held for one to two minutes during which thermal equilibration could be accomplished. If the vegetables could be held in a relatively large mass to reduce thermal losses, blanching could be accomplished. The vegetables used in this study include peas (smooth and wrinkled-skin varieties), corn, lima beans, green beans, potatoes, carrots and beets.

SECTION V

MATERIALS AND METHODS

PRODUCTS AND PROCESSING TIMETABLE

Products chosen for this study were those grown and/or processed in large quantity in Wisconsin. The 1971 study was done on Alsweet peas, Midway corn, Slim Green green beans and lima beans (variety unknown), and consequently, to verify the 1971 study, these products were used in this study. Since there was concern regarding the response of the smooth-skin pea variety to the IQB process, Alaskan peas were also used. Two wrinkled-skin varieties, Alsweet and Perfection, were used. In addition to these four vegetables, the root crops, potatoes, carrots and beets, were also processed.

The effect of harvest date on the characteristics of blancher effluent was assessed by making blanching runs throughout the processing season. Experiments were conducted on three days for peas and corn, two days for lima beans and green beans and one day for potatoes, carrots and beets. Product forms and processing dates are given in Table 1.

All products used in this study were obtained from either the Sun Prairie, Merrill, or Waunakee plants of the Oconomowoc Canning Company, Oconomowoc, Wisconsin. Peas were taken from the production line immediately after inspection and just prior to blanching. They were transported to the pilot plant at the Department of Food Science, Babcock Hall, University of Wisconsin-Madison under water to minimize product deterioration. The blanching run was started within two hours of leaving the canning plant.

Table 1. PRODUCT FORMS AND PROCESSING DATES

Processing date	Product	Variety	Form
6/22/72	Peas	Alsweet	4 sieve
6/26/72	Peas	Alaskan	3 sieve
7/26/72	Peas	Perfection	3, 4, 5 sieve (mixed)
8/16/72	Corn	Midway	Whole kernel
8/31/72	Corn	Midway	Whole kernel
9/11/72	Corn	Midway	Whole kernel
10/ 3/72	Lima bean	Thorogreen	3 sieve
10/11/72	Lima bean	Thorogreen	3 sieve
10/ 9/72	Green bean	Slim green	3.8 cm.
10/10/72	Green bean	Slim green	3.8 cm.
10/31/72	Potatoes	Superior	0.64 cm. (1/4 in.) slice; medium
11/ 2/72	Beets	Ruby queen	0.64 cm. (1/4 in.) slice; medium
11/ 7/72	Carrots	Nantes	0.64 cm. slice; medium

Corn was taken out of the processing line immediately before the conventional blanching step. The corn had been washed and screened. It was also transported to the pilot plant under water.

Cut green beans were received from the Merrill, Wisconsin plant and were transported from the plant to Madison by truck. The green beans were blanched and further processed immediately after receiving them.

Lima beans were taken from the processing line immediately after inspection and were transported to the pilot plant under water.

Potatoes, carrots and beets were obtained from the Waunakee plant. All root crop products had been steamed and/or lye-treated, peeled, graded, and sliced. Medium slice (3.2 - 4.4 cm. diameter) was used in the blanching studies. Tests indicated that there was enzymic activity (peroxidase) even though the product had received a thermal treatment. The product was brought to the laboratory and processed immediately.

BLANCHING METHODS AND EQUIPMENT

Five blanching methods were investigated in this study and are shown in Table 2. The first method was IQB (individual quick blanch).

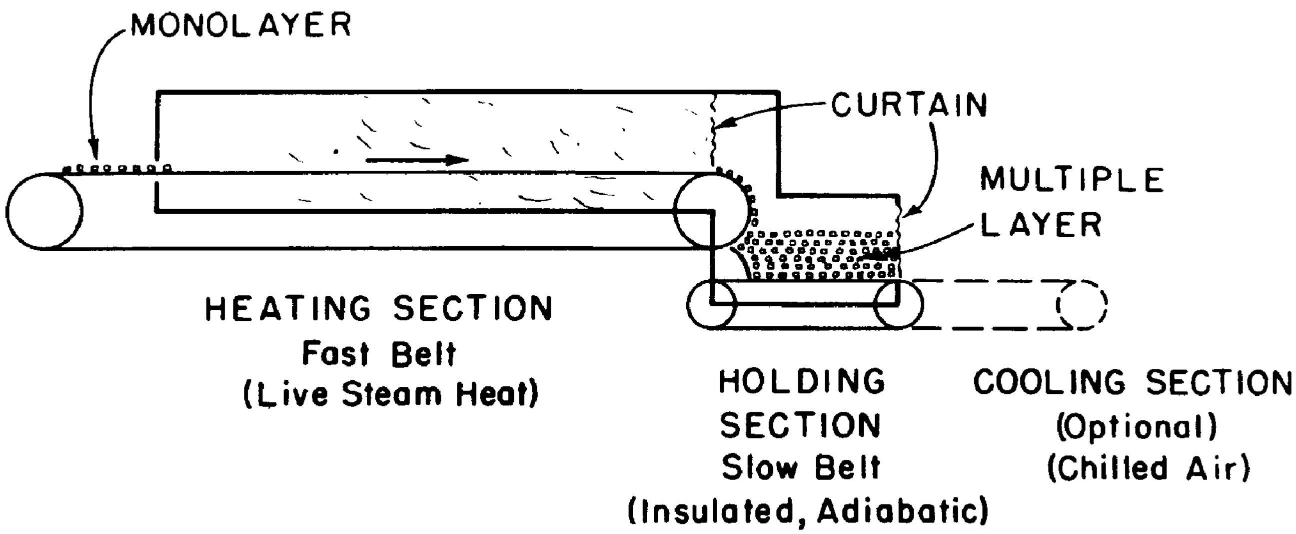
Table 2. BLANCHING METHODS

Method	Peas	Corn	Lima beans	Green beans	Potatoes	Carrots	Beets
IQB	x	x	x	x	x	x	x
IQB with predrying	x	x	x		x		x
IQB heat only	x	x	x				
Deep bed steam	x	x	x	x	x	x	x
Pipe	x	x	x	x			

The equipment was the same as that described in an earlier publication[3] and was on loan from the Western Regional Research Laboratory.

In essence the equipment consisted of two separate belt units, the first of which was approximately 91.4 cm. (3 ft.) by 21.6 cm. (8.5 in.) and the second of which was approximately 122 cm. (4 ft.) by 20.3 cm. (8 in.). The first unit was the heating section and had a feed hopper through which a single layer of product could be discharged onto the moving belt. The residence time in this unit could be varied from 20 sec. to 2.5 min. The second unit, the hold unit, had adjustable belt speed and tunnel length. Tunnel length was adjusted by changing the length of the cover on the unit. In all experimental runs reported here, the effective belt length was 30.5 cm. (1 ft.). A diagram of the IQB unit is shown in Figure 1.

Figure 1. IQB BLANCHING UNIT



The heat unit was heated by live steam which was distributed by two pipe distributors, one below and one above the belt. The distributor below the belt directed the steam parallel to the belt so product would not be blown off the belt, and the distributor above the belt was directed toward the cover on the unit. The hold section was heated indirectly by steam in two copper coils, one on each wall of the unit. The steam condensate and excess steam from this section was used to preheat the belt going into the hold section. The hold section was separated from the heat unit by a short transfer zone with a canvas curtain. Some steam leakage did occur from the heat unit into the hold unit.

The IQB unit was equipped with effluent drains on both the heat and hold units. Although the volume of effluent from each unit was recorded separately, analysis and reporting of the data were done on the total.

The second blanching method was IQB with predrying. For predrying, the vegetables were cycled through a 183 cm. (6 ft.) long by 30.5 cm. (1 ft.) wide vibrating bed dryer. Air at 71-82 C (160-180 F) (dry bulb) was passed up through the vegetable bed, and the vegetables were predried to approximately a 6% weight reduction. A 6% weight reduction was established based on results in the 1971 study. It was found that at higher weight reduction irreversible dehydration occurred (i.e. the product would not rehydrate to initial wet weight) and product quality was adversely affected (most notably through excessive skin rupture or excessive browning).

The third blanching method (IQB heat only) utilized only the heat belt of the IQB unit. Immediately after going through the heating unit the product was discharged into plastic buckets. Product was held in the buckets until canning.

The fourth method was deep bed steam blanching. The heat section of the IQB unit was used for this method also. The product was discharged onto the belt in a 6.4-7.6 cm. (2.5-3 in.) deep layer. Residence time in the unit was 2.5 min. for all deep bed blanching trials.

The fifth blanching method evaluated was the commercial method--pipe blanching. The unit consisted of 122-152 m. (400-500 ft.) of 11.4 cm. (4.5 in.) diameter stainless steel pipe. The length was variable so that the residence time could be adjusted. Product was metered into the pipe at a preset rate so that the water to product ratio was constant. After blanching, the product was dewatered at a dewatering reel and was further processed. The blanch water was then screened, make-up water was added and the water recycled into the pipe. Water and vegetables in the pipe blancher were heated by direct steam injection.

Blanching times used in the IQB heat/hold sections were determined by making simple observations on the pipe blanching operation. For peas, it was observed that conventional pipe blanching operation resulted in peroxidase inactivation and, therefore, peroxidase inactivation was the criterion for establishing heat/hold times in IQB. Appropriate heat/hold times were determined by the procedure described in Lund et al.[4] For corn and lima beans, water temperature in pipe blanching was approximately 77 C (170 F) and, consequently, heat/hold times were chosen that would result in a final corn or lima bean temperature of 77 C. Green beans were also pipe blanched at 77 C but the conventional IQB process could not be used. With green beans, the function of blanching is to activate the enzyme pectin methyl esterase which prevents sloughing of the green bean following canning. Since the enzyme is inactivated at temperatures above 82 C (180 F), the IQB heat section could not be heated with 100 C (212 F) steam. Therefore, a steam-air mixture at 79 C (175 F) was used in the IQB heating section. Heat/hold times were chosen that would result in an equilibrated temperature of 77 C. For potatoes, carrots and beets, a direct comparison to pipe blanching could not be made since these products are not usually blanched prior to canning. The only heat treatment these products receive prior to retorting is in the peeling operation. These products were included in the IQB and deep-bed experiments, however, since they are blanched prior to freezing and some processors have experienced undesirable color changes (particularly with beets and potatoes) which can be avoided by blanching after slicing or dicing. Blanching conditions were chosen such that peroxidase was inactivated. For deep-bed blanching, all vegetables were blanched for 2.5 minutes, the maximum residence time of the IQB heat section. Blanching conditions for all vegetables are shown in Table 3.

Table 3. BLANCHING TIMES AND TEMPERATURES[a]

Commodity	IQB	Heat only	Deep bed	Pipe
Peas	30 sec/100 C heat 45 sec hold	30 sec/100 C	2.5 min/100 C	4 min/93 C
Corn	20 sec/100 C heat 30 sec hold	20 sec/100 C	2.5 min/100 C	1.5 min/77C
Lima beans	20 sec/100 C heat 80 sec hold	20 sec/100 C	2.5 min/100 C	4 min/77 C
Green beans	20 sec/82 C heat 80 sec hold		2.5 min/82 C	2 min/77 C
Potatoes	60 sec/100 C heat 60 sec hold		2.5 min/100 C	
Carrots	45 sec/100 C heat 60 sec hold		2.5 min/100 C	
Beets	45 sec/100 C heat 60 sec hold		2.5 min/100 C	

[a] All time/temperature combinations resulted in negative peroxidase except for green beans. Time/Temperature (C).

For each experimental run, three 9.09 kg. (20 lb.) batches of the vegetable were treated by one of the four steam blanching methods. Initial weight, weight after drying (if the product was predried), and weight after blanching were recorded. For each 9.09 kg. run, all waste water generated by processing the vegetable in the blancher was measured. A composite sample of the waste water was subjected to analysis for the following: 1) BOD_5, 2) COD, 3) total solids, 4) suspended solids, 5) soluble phosphorus, 6) total phosphorus, 7) total organic nitrogen, 8) NH_3-Nitrogen, 9) NO_3-Nitrogen, 10) NO_2-Nitrogen, 11) volatile solids, 12) suspended volatile solids, and

13) pH. Part of the analyses were performed by the Wisconsin Department of Natural Resources. In all cases the standard methods for analyses were used[6].

In order to report waste water generation on the basis of amount of product processed, a blank was determined for each run by operating the equipment with the steam on and the belts moving for a period of time equal to the time to process the 9.09 kg. lot. Equipment effluent (due to heat losses from the equipment, heating the belt and any water carried in the steam line) was measured and this value subtracted from the volume generated during the actual run. All analysis values were corrected by the resulting dilution factor. Immediately following blanching, samples were filled into 303 x 406 cans to the appropriate fill weight, brine added, cans sealed and retorted in a Steritort following the heat/cool process used in the canning plant.

For the pipe blancher, effluent was collected at the dewatering reel and subjected to the same analyses as other samples. Water usage was monitored by a water meter in the water make-up line and was recorded daily. By knowing the daily case pack on the line, the liters of water per case of product could be calculated. Since the pipe blanching water was heated by direct steam injection, the effluent generated by the system was larger than that calculated from the water make-up readings. To adjust for the steam condensation in heating the product up, it was assumed that 4.23 kg. (9.3 lb.) of steam would condense for every 45.5 kg. (100 lb.) of product being heated 38.0 C (100 F). This resulted in 91.7 liters of steam condensation per kkg. of product (22 gal/ton). This value has been added to all pipe blancher values as calculated from water meter readings. Waste generation reported for the pipe blanching system will still be low since this does not account for heat losses from the piping system. However, for the system we monitored heat losses would probably not contribute more than 8.3-20.9 l./kkg. (2-5 gal/ton) of product processed.

To insure that representative samples of waste water were being collected from the pipe blancher, on some occasions (at least two days for each vegetable), water samples were collected at two-hour intervals. Results indicated that within two hours of start-up the blancher water was in steady state. Therefore, all samples were taken at least two hours after start-up. For later evaluation and comparison, several cases of canned vegetables processed at the same time the experimental samples were processed were brought to the laboratory.

PRODUCT EVALUATION

After blanching, the product was hand packed into 303 x 406 cans, boiling water and the appropriate volume of concentrated brine were added and the cans were sealed. The cans were then thermally processed in a Steritort using rotation speed and heat/cool times identical to those used in the canning plant. Product was then stored at 32 C (90 F) along with conventionally processed product which had been obtained from the canning plant. Product evaluations were conducted at 1, 3, 6 and 9 months' storage. The tests performed on each product are shown in Table 4. Standard procedures were followed for all tests. The method of Van Buren et al.[7] was used for the slough test on green beans. At each evaluation a five-can subsample for each experimental process and conventional process was analyzed.

Product quality was assessed by triangle taste test comparing each experimentally processed product to the corresponding control process product (canned product obtained from the canning plant). Taste testing was conducted in the Sensory Evaluation Laboratory of the Department of Food Science using personnel who were trained in sensory evaluation. Differences could be assessed on the basis of color, texture or flavor and preference was noted. To streamline the presentation of sensory evaluation data, two pieces of information were generated. The first consists of three numbers separated

Table 4. PRODUCT EVALUATION TESTS

Test	Peas	Corn	Lima beans	Green beans	Potatoes	Carrots	Beets
Taste panel	x	x	x	x	x	x	x
Can vacuum	x	x	x	x	x	x	x
Drained weight	x	x	x	x	x	x	x
Brine sediment	x						
Slough				x			
Percent splits	x			x			

by slashes such as 10/5/5. The first number (10) is the number of correct judgments which preferred the experimentally blanched canned product; the second number (5) is the number of correct judgments which preferred the control sample; and the last number (5) is the number of correct judgments which showed no preference. The second piece of information was the level of distinction between samples. There was either no significant difference (NS) or differences were identifiable at the 0.1%, 1% or 5% level.

SECTION VI

RESULTS AND DISCUSSION

FLOW VARIABILITY OF BLANCHING WASTES

During the processing season daily water meter readings were recorded for water usage in the pipe blancher for peas, corn, and green beans. Examination of the data showed that the most consistent characteristic was the extreme variability in water used per case or ton of vegetable. The data were so scattered that it is tenuous at best to draw conclusions. However, in the hope of comparing IQB to pipe blanching, average water usage rates were calculated. An example of variability of data is the range of data reported for green bean blanching. On 8/24/72 there was a reported 24.2 l./case (6.4 gal/case) water usage in the pipe blancher; whereas on 9/16/72 only 0.45 l./case (0.12 gal/case) was recorded. This is over a 50-fold difference! In pea blanching, on 6/27/72, 6.6 l./case (1.75 gal/case) was recorded for the pipe blancher compared to 0.33 l./case (0.088 gal/case) on 7/19/72, a 20-fold difference. This tremendous variability contributes to many misinterpretations regarding water usage in blanching operations. One factor responsible for variability is incomplete knowledge of the blanching system. In our case we were not informed that the blancher could be filled from two separate sources, one at the inlet end and one at the discharge end. Consequently, we only monitored water inlet from one source. Once this was recognized we were able to screen the data to assure that a representative value was reported. A second factor responsible for variability of flow is the lack of control on the blanching unit operation. Many times the blancher is not equipped with a flow regulating device but rather there is just a water line bringing water into the system. The foreman or worker merely opens a water valve to the blancher and has no guidance as to the appropriate flow rate to use. Therefore, on some occasions flow is very high, while on others it is very low.

In addition to the variability of flow between days, there is also variability of flow within a day. An example of water flow from blanching during one day of processing for peas, corn, green beans and lima beans is shown in Table 5. The percent total solids of the blancher effluent is also given. It can be seen that there is considerable variability in the water usage pattern throughout the processing day. This variability reflects the cyclic nature of the blanching operation in that the blancher is generally drained and refilled several times during the operating day. This cleanup is necessitated by the fact that the solids leached from the tissue during blanching undergo oxidative and thermal degradation to very flavorful compounds. These compounds can produce off-flavor in the final product unless they are removed periodically. For peas the blancher was refilled every 6-8 hours, for corn every 12 hours, and for lima beans every six hours. For green beans the blancher was refilled every six hours but no make-up water was added between refills. Under these conditions the total solids in the blanch water varies considerably, for example, from 0.55% TS to 1.35% TS. With the other vegetables the % TS is kept relatively constant by the addition of make-up water.

The data reported in Table 5 for lima beans are from the 1971 study. No data are available on water usage for lima beans for 1972 due to a change in blanching conditions. In 1971, the water make-up rate was approximately 76 l./case (20 gal/case), about ten times higher than that reported for the other vegetables. At the end of the 1971

Table 5. HOURLY MAKE-UP FLOW RATES AND TOTAL SOLIDS CONTENT OF PIPE BLANCHER WATER FOR PEAS, CORN, LIMA BEANS AND GREEN BEANS

Time	Peas		Corn		Lima beans		Green beans	
(hrs)	% TS	l./hr	% TS	l./hr	% TS	l./hr	% TS	l./hr
2	2.31	719	2.47	1703	0.59	24600	0.71	8880
2.5	2.15	590	2.58	1363				
3	2.24	795	2.50	1363				
3.5	2.90	636	2.30	1363				
4	2.90	689	2.05	1817	0.39	20250	1.12	0
6	2.70	708	1.09	1249	0.62	30470	0.63	6230
8			2.24	1400	0.43	15030	1.01	0
10			3.00	1400	0.37	20530	0.97	0
12			2.79	4126			0.55	9750
14			2.12	265			1.23	0
16			2.26	2725			1.35	0
18			1.95	1779				

processing season this observation was made to the plant personnel who immediately sought to correct the situation for 1972. The high water usage rate was the result of the foaming problem associated with lima bean blanch water. In 1972, several corrective actions were taken: 1) use of an antifoam agent in the blanch water, 2) use of hard water instead of soft and 3) maintenance of a full reservoir prior to the pump (eliminated air entrapment). Since the water make-up line was hard water and fed several pieces of equipment simultaneously, it was impossible to monitor water addition rates. However, after conversations with plant personnel, it was estimated that water usage rates for lima beans were about the same as those for corn.

CONDENSATION OF RAW DATA

In this type of study volumes of raw data can be obtained and much of it can, in turn, be multiplied considerably by calculations. In order to simplify the examination of data and to reach the really pertinent information obtained in this study, the raw data were condensed and only the pertinent calculations were performed. Many more calculations can be done but they do not serve to demonstrate more effectively the results contained herein.

The raw data for each of the blanching runs are given in the Appendix in Tables A1 - A14. The first table for each product presents the physical characteristics of the run such as belt loadings, effluent generated (expressed as l./case), product yield and solids lost as product. "Belt loading" results will be discussed in a later section. "Effluent generated" was calculated from the volume of waste collected per unit of raw product. "Product yield" is the ratio of blanched weight to initial weight times one hundred. "Solids lost as product" represents the solids in the blanch water expressed on the basis of product equivalents. For this calculation it was assumed that peas were 20% total solids, corn was 25%, lima beans were 32.5%, green beans were 10%, potatoes were 20.2%, carrots were 11.8% and beets were 12.7%. These values are from USDA Handbook No. 8.

The second table presenting raw data on each blanching run for each product characterizes the effluent. All of the data are expressed as ppm or % and represent the concentration of the particular component in the effluent. A more convenient way of expressing these data for discussion purposes is to express the water characteristics on the basis of kkg. of processed product. This was done and selected characteristics will be presented in later discussions.

The notation used in the tables to describe the blanching treatment is relatively straightforward. IQB stands for individual quick blanch, the "-0" or "-number" represents the predrying treatment (0 means no predrying; number expresses the % weight reduction in predrying), the "-sec" represents the heat only process of IQB and deep bed represents deep bed steam blanching. Pipe refers to pipe blanching, the control.

Examination of the raw data shows that several variables had no effect on blanching characteristics of the product. For peas there did not appear to be an effect due to variety or harvest date on blanching characteristics. Therefore, the data within one blanching treatment could be averaged to simplify presentation. Similarly with corn, there did not appear to be an effect of harvest date. Therefore, the data were averaged within each blanching treatment. Lima beans, green beans, potatoes, beets and carrots also showed no harvest date effect. Therefore, averages are used in discussing the results. It should be pointed out that the variable harvest date is not the same as the variable maturity. For example, although corn may be harvested on different dates it may be of the same maturity and consequently there can still be a maturity effect. With corn in particular, it might be suspected that there would be a difference in blancher effluent for mature versus immature corn.

Although several parameters were measured on the blancher effluent only a few will be discussed. Probably the most important parameters are BOD_5, total organic nitrogen and total phosphorus since the relative concentrations of these three components are used to assess the response of the waste to biological waste treatment. Consequently in discussing the data, only these three parameters will be discussed.

PEA BLANCHING

A summary of the pea blanching data is given in Table 6.

Table 6. SUMMARY OF PEA BLANCHING DATA[a]

Blanching treatment[b]	Effluent generation (1./kkg)	BOD_5 (kg/kkg)	Total organic nitrogen (kg/kkg)	Total phosphorus (kg/kkg)	Product yield (%)	Solids lost as product (%)
IQB-6.9	146	1.8	0.09	0.02	88.8	1.53
IQB-0	225	2.6	0.13	0.04	89.3	2.07
30 Sec	209	2.5	0.13	0.03	90.4	2.09
Deep bed	313	4.3	0.22	0.05	83.3	3.11
Pipe	384	3.0	0.17	0.05	--	--

[a] Expressed per kkg of blanched product. See Tables A1 and A2 for complete data.

[b] IQB-6.9 means IQB with a 6.9% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
30 Sec means heat section only of IQB.
Deep bed means deep bed steam blanching.
Pipe means pipe blanching.

The first important observation is that all of the steam blanching methods resulted in less effluent generation than pipe blanching. Predrying by an average of 6.9% weight reduction reduced waste generation by 62% while deep bed blanching reduced the waste stream by 18%. As expected, predrying showed less generation of waste than IQB or 30 sec. heat treatments. Predrying the surface of the pea allowed the condensed steam to rehydrate the surface rather than running off. The IQB-0 and 30 sec. heat treatments resulted in nearly the same total effluent generation indicating that most of the effluent is generated in the heat section of IQB from steam condensation.

The value of 225 1./kkg (54 gal/ton) reported here for IQB-0 agrees quite well with the 200 1./kkg (48 gal/ton) for steam blanching peas as reported by Ralls et al.[8] and with the theoretical value obtained when a mass balance is performed on the unit operation. In Ralls et al. study the loading rate was only 2 kg/m^2 (0.4 $pound/ft^2$) of belt suggesting that they had the equivalent of an IQB heat stage. The residence time, however, was much longer than the 30 sec. used in IQB.

The deep bed steam blanching treatment resulted in 313 l./kkg (75 gal/ton product), nearly 50% more than IQB blanching. The greater effluent generation is due to two factors: 1) overheating of some of the tissue resulting in greater juice loss and 2) a lower surface water holding capacity of the heated bed of peas. The first factor is evident from the higher BOD_5, nitrogen and phosphorous values reported for the deep bed treatment. Also, the solids lost as product is nearly 50% more than for IQB. The second factor, lower water holding capacity of the bed of peas, is a result of the higher mass average temperature of the peas in the deep bed treatment. With the residence time of 2.5 minutes the bed temperature was much higher and consequently the viscosity of the water and the surface tension of waterwere lower resulting in more water running off.

The 384 l./kkg (92 gal/ton) reported here is much lower than other values reported for water blanching systems. Weckel et al.[1] reported a waste water generation of 1420 l./kkg (340 gal/ton) for a pipe blanching while Ralls et al.[8] reported 4170 l./kkg (1000 gal/ton) for a draper-type water blancher. The value reported here reflects a very important concept recognized by the canning plant personnel. They have cut back the water make-up on a regular basis while continuously checking product quality. This has allowed them to cut water usage drastically through control on the process. The high value reported by Ralls et al.[8] may not necessarily reflect excessive waste generation with the draper-type blancher. Rather it may reflect the batch-type nature of the way in which the experiment was conducted. Perhaps more peas could have been processed in the blancher before the water had to be changed. Also, a feed and bleed system would reduce water usage.

The BOD_5 reported here for steam and pipe blanching corresponds quite well to the data of Ralls et al.[8]. They reported a COD of 8.3 kg/kkg (16.6 lb/ton) for steam blanching and if we assume a BOD/COD ratio of 0.60 this would result in a BOD_5 of about 5 kg/kkg (10 lb/ton). The BOD/nitrogen/phosphorous ratio was surprisingly constant with an average of 82/4.4/1 (range 55-117/3.1-7.6/1.This indicates that this waste has an adequate carbon to nitrogen to phosphorous ratio for biological treatment.

Finally, the product yield is given in Table 6. Product yield was quite constant between the IQB treatments but deep bed steam blanching resulted in considerably greater loss of yield. For deep bed steam blanching this lower yield is due to tissue breakdown and lower water holding capacity of the peas, as explained earlier. For IQB blanching most of the weight loss is also a result of the lower moisture holding capacity of the surface. From experiments done in 1971, a cold pea can hold up to 15% by weight as surface moisture. After blanching, the surface is nearly dry even though steam has condensed on the surface. The hot surface can hold only up to 6% by weight as water and thus loss of surface moisture would account for up to 9% weight loss.

The product yield value would appear to be too low for economic consideration of IQB; however, the process should be evaluated primarily on the basis of solids lost since this value represents true product loss. Product yield reflects the loss of surface water as well as product loss. It would be anticipated that hot water blanching would result in even greater solids loss as reported by Lee[9].

The results of objective evaluation of peas is shown in Table 7. It is noticed that all of the can vacuum values for the experimentally blanched samples are higher than that for pipe blanched samples. This is due to the fact that the fill water temperature was higher in the experimentally blanched samples. In the laboratory the fill water temperature was near 96 C (205 F) whereas in the canning plant it was 82-88 C (180-190 F). This difference could account for the difference in can vacuum. This demonstrated, however, that peas could be successfully steam blanched prior to canning and that there was adequate air removal from the tissue. The can vacuum decreased slightly upon storage, as expected.

The drained weights of all steam blanched samples were higher than those of the control. This was not likely the result of the blanching treatment but rather was the result of a slight overfill. The fill weight was 292.5 g. (10.3 ounces) and the resulting drained weight averaged 320.9 g. (11.3 ounces), a 28 g. (one ounce) weight gain upon retorting and cooling.

Brine sediment values reflect a problem associated with predrying prior to IQB. The brine sediment values were consistently higher for the predried samples. This is due to skin splitting that occurs during predrying and subsequently comes off in the agitated retort operation. Compared to pipe blanching, the other steam blanching systems are quite acceptable.

Finally, the percent split data are presented. Although the percent split is higher for the steam blanched samples, this apparently was not detrimental to product quality. The brine sediment value did not seem to reflect the split damage. Greater percent splits in steam blanching compared to water blanching may reflect the difference in heating rates. With steam blanching the temperature increases very rapidly resulting in a rapid expulsion of tissue

Table 7. SUMMARY OF OBJECTIVE EVALUATION OF PEAS[a]

Blanching treatment	Can Vacuum (cm. Hg. vacuum)							
	Months of storage							
	1		3		6		9	
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
IQB-6.9	34.8	26.4-39.9	31.5	20.6-38.4	31.8	22.1-36.8	32.0	27.9-36.1
IQB	34.0	27.2-37.3	32.3	20.8-41.1	32.0	22.4-38.4	30.2	24.4-36.8
30 Sec	29.7	21.6-36.6	29.5	18.3-36.8	28.4	21.6-31.8	29.7	25.4-31.8
Deep bed	31.5	23.4-36.8	30.7	23.4-34.5	28.4	19.8-33.3	29.5	26.4-31.5
Pipe	21.6	17.0-30.0	21.6	13.7-28.4	20.8	16.0-26.9	17.5	10.2-24.9
	Drained Weight (g.)							
IQB-6.9	320.4	312.1-324.3	326.8	315.8-337.1	322.6	315.8-328.0	320.4	313.0-324.6
IQB	316.4	311.0-323.2	319.2	311.3-326.9	318.6	314.4-320.9	320.1	311.5-328.0
30 Sec	315.8	308.4-320.1	313.5	307.6-317.5	312.7	309.0-315.5	315.0	309.8-318.4
Deep bed	337.4	326.6-343.6	337.4	329.4-345.3	332.3	325.7-337.7	334.3	326.6-341.9
Pipe	295.1	285.7-305.6	301.0	291.1-307.0	301.6	293.4-305.6	302.5	299.1-305.9
	Brine Sediment (%)							
IQB-6.9	6.29	5.05-8.18	7.23	5.05-10.36	5.41	5.24-5.57	4.59	4.46-4.72
IQB	3.82	3.69-3.91	4.23	3.88-4.56	3.81	3.44-4.17	3.38	3.33-3.43
30 Sec	4.09	2.97-5.06	3.73	2.81-5.23	3.41	2.98-3.81	4.80	1.79-8.30
Deep bed	3.96	2.45-6.12	3.83	3.45-4.37	4.07	3.28-5.06	3.13	2.88-3.39
Pipe	5.30	3.23-8.76	3.59	2.36-5.27	4.05	2.15-7.00	3.89	2.16-6.08

[a] Each average consists of at least nine observations.

Table 7 (continued). SUMMARY OF OBJECTIVE EVALUATION OF PEAS[a]

Blanching treatment	Splits in Peas (%)							
	Months of Storage							
	1		3		6		9	
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
IQB-6.9	38	30-48	35	29-39	35	26-45	30	26-35
IQB	28	26-30	41	39-43	30	24-34	24	19-30
30 Sec	36	29-40	36	29-43	27	21-37	30	20-40
Deep bed	40	32-56	33	28-39	28	19-37	29	23-34
Pipe	18	14-29	22	13-29	21	14-27	20	16-25

[a] Each average consists of at least nine observations.

gases. This sudden expansion of gases may fracture in the peas resulting in eventual splitting. With water blanching, on the other hand, the temperature rise is slow enough to allow tissue gases to diffuse out of the tissue without developing excessive pressures.

A summary of the subjective evaluation of peas is given in Table 8. From these data it is concluded that steam blanching resulted in a canned pea product at least as good as that produced with pipe blanching. In those cases where there was a significant difference, the steam blanched product was generally preferred.

In conclusion, the study with peas indicates that IQB can be successfully used for pea blanching with a 40% decrease in liquid waste generation compared to pipe blanching. Compared to deep bed steam blanching, IQB produced 28% less effluent and less product loss. IQB with predrying is not recommended due to significant increases in brine sediment. Product quality as evaluated by objective and taste panel tests was at least as good for IQB as for pipe blanching.

CORN BLANCHING

A summary of the corn blanching data is given in Table 9.

Table 8. SUMMARY OF SUBJECTIVE EVALUATION OF PEAS

Blanching treatment[a]	Storage time (months)[b]			
	1	3	6	9
IQB-6.25-4-Als	0.1% 8-4-4	1% 8-5-3	0.1% 11-2-3	0.1% 7-5-8
IQB-0-4-Als	5% 8-3-2	1% 9-4-2	1% 6-3-6	0.1% 7-6-7
30 Sec-4-Als	NS	0.1% 12-3-2	0.1% 9-2-3	0.1% 12-5-3
Deep bed-4-Als	0.1% 13-4-3	NS	0.1% 7-6-1	0.1% 12-3-4
IQB-7.0-3-Ala	5% 5-6-2	NS	0.1% 5-7-7	5% 3-7-6
IQB-0-3-Ala	NS	NS	NS	NS
30 Sec-3-Ala	1% 4-5-5	NS	NS	5% 5-5-4
Deep bed-3-Ala	NS	NS	1% 2-6-9	NS
IQB-7.5-Perf.	NS	--	1% 4-6-7	NS
IQB-0-Perf.	NS	--	NS	NS
30 Sec-Perf.	NS	NS	--	NS
Deep bed-Perf.	NS	NS	--	NS

[a] IQB-6.25 means IQB with a 6.25% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
30 Sec means heat only stage of IQB.
Deep bed means deep bed steam blanching.
4 or 3 refers to sieve size; Perfection was sieve size 3, 4 and 5.
Als means Alsweet; Ala means Alaskan; Perf. means Perfection.

[b] Each sample was compared to a pipe-blanched, canned control. The control was canned the same day as the experimental sample. The top number is the level of significance and the bottom three numbers represent number of judges preferring experimental sample, control and no preference, respectively. NS means no significant difference.

Table 9. SUMMARY OF CORN BLANCHING DATA[a]

Blanching treatment[b]	Effluent generation (l./kkg)	BOD_5 (kg/kkg)	Total organic nitrogen (kg/kkg)	Total phosphorus (kg/kkg)	Product yield (%)	Solids lost as product (%)
IQB-7.5	86	1.4	0.017	0.008	93.1	0.81
IQB-0	125	2.7	0.039	0.020	97.1	1.61
20 Sec	125	3.0	0.037	0.019	97.4	1.52
Deep bed	163	4.4	0.049	0.028	94.2	2.42
Pipe	730	4.9	0.089	0.034	--	--

[a] Expressed per kkg of blanched corn. See Tables A3 and A4 for complete data.

[b] IQB-7.5 means IQB with a 7.5% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
20 Sec means heat section only of IQB.
Deep bed means deep bed steam blanching.
Pipe means pipe blanching.

As with pea blanching, all of the steam blanching methods produced less effluent than pipe blanching. IQB without predrying reduced effluent generation by 83% compared to pipe blanching while a 7.5% weight reduction prior to IQB reduced effluent generation by 88%. The effluent generated per ton of corn is considerably less than that for peas because of the difference in the nature of the surface of the two vegetables. Cut corn surfaces expose starch which upon heating can absorb water resulting in less water loss. On the other hand, the BOD_5 for corn was about the same as that for peas indicating that water that did drain off corn carried with it more solids. In pipe blanching, water usage for corn was nearly double that for peas. This reflects the fact that with corn, the blanching process is primarily a wash step to remove reducing sugars and other components that may contribute to brown color development during thermal processing. In some plants, corn is not blanched prior to canning. Weckel et al.[1] reported an average of 1043 l./kkg

(250 gal/ton) for pipe blanching corn. As with peas, deep bed steam blanching resulted in greater effluent generation than IQB but it was still considerably less than pipe blanching.

The BOD/N/P ratio for corn averaged 151/2.1/1 (range 88-237/1.5-2.9/1) indicating that the waste may be low in nitrogen for biological treatment. From Table A4 the BOD/COD ratio was 0.78. Soderquist et al.[10] reported a BOD/COD ratio of 0.75 for corn wastes. That figure, however, included waste generated at unit operations in addition to blanching.

With respect to product yield there are some interesting observations. First, with predrying the product yield is lower than with IQB without predrying. This reflects the fact that the corn surface, once dehydrated, is very difficult to rehydrate and thus this yield reflects losses of product solids and loss of reabsorbing capacity of the surface. Deep bed steam blanching resulted in greater product loss primarily through solids lost in the effluent.

Table 10 presents the results of the objective evaluation on steam blanched and pipe blanched corn. As with peas, can vacuum for the steam blanched samples is higher than that for the pipe blanched sample. This reflects the lower water fill temperature used in the canning plant compared to the laboratory pilot plant. There was no significant difference in drained weight between any of the samples.

A summary of the subjective evaluation of corn is given in Table 11. There appears to be a significant difference between steam blanched and pipe blanched samples but the preference is not consistent. It was observed that the steam blanched samples were darker in color than the pipe blanched samples attesting to the fact that the blanch step is primarily a wash step for corn. This darker color, however, did not manifest itself in consumer preference meaning that perhaps blanching does not have to serve as a wash step if the consumer cannot detect the color difference.

Table 10. SUMMARY OF OBJECTIVE EVALUATION OF CORN[a]

Blanching treatment	Can Vacuum (cm. Hg. vacuum)						
	Months of Storage						
	1		3	6		9	
	Avg.	Range	Avg.[b]	Avg.	Range	Avg.	Range
IQB-7.5	26.9	21.6-30.7	27.9	21.8	15.2-27.4	23.1	21.6-25.4
IQB	31.8	29.0-35.1	32.5	26.7	20.8-34.8	27.7	25.4-32.0
20 Sec	28.2	23.6-36.6	32.3	23.6	19.1-31.8	27.7	22.6-34.3
Deep bed	26.4	22.6-31.8	31.0	20.6	14.5-31.2	24.6	51.8-31.8
Control	23.6	18.5-28.7	18.5	17.5	16.5-19.6	22.6	17.8-26.2
	Drained Weight (g)						
IQB-7.5	327.7	326.9-294.1	328.0[b]	326.9	321.8-330.3	322.9	317.8-329.4
IQB	324.6	322.6-327.7	317.8	318.4	315.8-320.1	323.5	316.1-328.3
20 Sec	325.5	320.9-330.9	317.2	315.8	314.7-317.2	321.2	320.6-322.1
Deep bed	331.7	330.3-332.8	326.9	327.7	322.6-330.3	330.3	328.3-332.3
Control	327.2	310.4-343.1	304.4	324.6	315.8-339.4	322.1	313.5-337.1

[a] Each average consists of at least nine observations.

[b] Only one series of samples was evaluated after three months' storage.

In conclusion, IQB and deep bed steam blanching both result in drastic reductions of effluent generation in corn blanching. However, in both cases a darker product resulted after retorting. To maintain a bright golden yellow color, corn would have to be thoroughly washed prior to steam blanching. This wash step, in turn, defeats the purpose of steam blanching since the wash step would create another high volume-low load effluent steam. Therefore, the

Table 11. SUMMARY OF SUBJECTIVE EVALUATION OF CORN

Blanching treatment[a]	Storage time (months)[b]			
	1	3	6	9
IQB-7.5	1% 4-10-4	1% 4-7-3	0.1% 2-17-4	NS
IQB-0	5% 3-8-5	0.1% 0-11-3	NS	5% 3-4-6
20 Sec	NS	1% 9-4-1	NS	1% 2-9-4
Deep bed	5% 3-8-3	0.1% 6-9-1	NS	NS
IQB-7.5	0.1% 8-13-1	--	0.1% 2-12-7	1% 6-6-5
IQB-0	NS	--	NS	1% 7-3-6
20 Sec	NS	--	0.1% 3-7-2	0.1% 10-6-2
Deep bed	NS	--	1% 7-9-2	NS
IQB-7.5	1% 8-5-4	--	0.1% 10-6-5	0.1% 18-3-4
IQB-0	1% 10-8-0	--	1% 9-7-2	0.1% 5-16-4
20 Sec	0.1% 18-3-1	--	NS	0.1% 16-3-3
Deep Bed	0.1% 17-2-0	--	0.1% 11-7-2	0.1% 11-5-3

[a] IQB-7.5 means IQB with 7.5% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
20 Sec means heat only stage of IQB.
Deep bed means deep bed steam blanching.

[b] Each sample was compared to a pipe-blanched, canned control. The control was canned the same day as the experimental sample. The top number is the level of significance and the bottom three numbers represent number of judges preferring experimental sample, control and no preference, respectively. NS means no significant difference.

advantage of producing a bright yellow corn must be weighed against the disadvantage of creating an effluent stream and the cost of its subsequent treatment. Since blanching of corn must be done when corn is packed into No. 10 cans, there is still a use for steam blanching.

LIMA BEANS

Lima bean blanching results are summarized in Table 12.

Table 12. SUMMARY OF LIMA BEAN BLANCHING DATA[a]

Blanching treatment[b]	Effluent generation (l./kkg)	BOD_5 (kg/kkg)	Total organic nitrogen (kg/kkg)	Total phosphorus (kg/kkg)	Product yield (%)	Solids lost as product (%)
IQB-5.0	67	0.35	0.02	0.004	97.5	0.24
IQB-0	171	1.7	0.12	0.02	93.4	0.86
20 Sec	133	2.4	0.06	0.015	96.7	0.54
Deep bed	238	3.5	0.17	0.04	88.7	1.38
Pipe	821	0.65	0.02	0.01	--	--

[a] Expressed per kkg of blanched product. See Tables A5 and A6 for complete data.

[b] IQB-5.0 means IQB with a 5.0% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
20 Sec means heat section only of IQB.
Deep bed means deep bed steam blanching.
Pipe means pipe blanching.

Results with lima beans parallel those obtained with peas and corn. The effluent generation values are similar to those reported for corn in Table 9 and reflects the water holding capacity of the surface of the lima bean. In lima bean processing the blanch step serves to partially rehydrate the dry lima bean seeds.

The pipe blanching method produced 821 l./kg (197 gal/ton) compared to only 171 l./kg (41 gal/ton) for IQB; IQB reduced effluent by 79%. Predrying reduced the effluent to only 8% of that for pipe blanching. The BOD/N/P ratio averaged 97/4.8/1 (range 32-205/1.1-7.8/1) indicating that lima bean blancher effluent has an adequate nutrient balance for biological waste treatment. The BOD/COD ratio was 0.76 (calculated from Table A6). Product yield figures indicate that lima beans rehydrate readily after the predrying step since the yield is greater than that for the other steam blanching methods. The difference between the yield values for IQB-0 and 20 sec reflect product loss and liquid loss in the hold section during IQB. The only difference between these two runs is the fact that the 20 sec experiment did not include the hold section. The liquid loss occurring in the hold section is also reflected in the higher effluent generation value reported for IQB-0 compared to 20 sec. Deep bed steam blanching resulted in the lowest yield and is partially accounted for in the solids lost. The other loss is accounted for in the decreased water holding capacity of the surface due to a higher mass average temperature of the deep bed blanched lima beans.

Results of the objective evaluation of lima beans is given in Table 13. It can be seen that can vacuum of all of the steam blanched samples is considerably lower than that for pipe blanched, canned product. This may have been due in part to can overfill in the experimental samples. Notice that most of the drained weights are greater for the experimentally blanched samples indicating that the can was overfilled. Upon retorting the lima bean absorbs water and expands. This can result in decreased can vacuum. Thus, the lower can vacuum for the steam blanched samples does not necessarily reflect poor tissue gas removal. The somewhat higher (8-10%) drained weights for the steam blanched samples could be corrected by filling at approximately 227-241 g. (8-8.5 ounces) rather than the current 256 g. (9.0 ounces) fill weight. Proper drained weight would then be achieved following retorting and can vacuum would probably be higher.

Although it was not recorded, there appeared to be more skins and suspended solids in the IQB predried sample. This was presumably

Table 13. SUMMARY OF OBJECTIVE EVALUATION OF LIMA BEANS

Blanching treatment	Can Vacuum (cm. Hg. vacuum)							
	Months of Storage							
	1		3		6		9	
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
IQB-5.0	15.0	11.4-21.6	17.0	15.2-19.1	17.0	10.2-20.3	14.7	11.4-17.8
IQB	15.7	9.7-21.6	17.8	13.5-21.8	18.8	14.7-22.6	16.3	11.9-20.6
20 Sec	12.7	12.2-13.0	17.0	14.5-19.6	17.8	14.2-21.1	15.7	15.2-16.3
Deep bed	12.4	6.4-20.3	16.3	14.0-19.1	13.7	10.2-17.9	14.5	8.9-17.8
Pipe	29.7	28.7-31.2	30.5	29.7-31.8	28.7	28.2-29.2	27.4	26.7-28.4
	Drained Weight (g.)							
IQB-5.0	395.3	381.4-413.6	368.3	362.3-373.2	386.0	372.8-394.9	400.4	374.5-414.7
IQB	307.3	299.6-315.0	317.8	295.1-340.2	338.5	296.8-380.3	334.3	299.9-368.6
20 Sec	296.8	277.8-315.8	303.6	283.4-323.5	298.2	279.7-317.5	301.3	278.6-324.0
Deep bed	341.7	338.7-343.5	341.1	335.0-343.9	341.1	336.9-345.3	344.2	338.0-349.7
Pipe	324.0	298.2-364.9	307.9	298.2-317.2	305.6	293.7-311.8	307.6	306.7-319.8

[a] Each average consists of at least three observations.

due to the rupture of skins during drying which were released during the agitated cook. On this basis it is doubtful if IQB with pre-drying is an acceptable process.

Subjective evaluation of lima beans is presented in Table 14. There was no clear trend in preference for either steam blanched or pipe blanched product. This probably reflects the fact that people usually do not have a specific idea of what good lima beans are supposed to taste or look like. The conclusion can be made that there is probably a difference but that it was not a striking enough

Table 14. SUMMARY OF SUBJECTIVE EVALUATION OF LIMA BEANS

Blanching treatment[a]	Storage Time[b] (months)			
	1	3	6	9
IQB-5.0	0.1% 9-6-1	0.1% 8-6-3	1% 8-5-4	NS
IQB-0	0.1% 8-10-0	0.1% 7-8-2	NS	0.1% 5-4-11
20 Sec	5% 6-7-2	NS	1% 4-7-6	0.1% 5-4-11
Deep Bed	NS	NS	0.1% 8-4-9	0.1% 5-4-11
IQB-0	NS	0.1% 6-8-5	NS	NS
20 Sec	NS	0.1% 7-4-7	0.1% 6-5-5	0.1% 4-6-6

[a] IQB-5.0 means IQB with a 5.0% weight reduction prior to drying.
IQB-0 means IQB with no predrying.
30 Sec means heat only stage of IQB.
Deep bed means deep bed steam blanching.

[b] Each sample was compared to a pipe-blanched, canned sample. The control was canned the same day as the experimental sample. The top number is the level of significance and the bottom three numbers represent number of judges preferring experimental sample, control and no preference, respectively. NS means no significant difference.

difference to allow development of a preference. There is no justification for discarding any of the steam blanching methods based on subjective evaluation.

In conclusion, IQB without predrying can be successfully applied to lima beans. Adjustment must be made in fill weight to arrive at the correct drained weight since there is more rehydration in the can with IQB blanched beans. Predrying results in a greater reduction in effluent generation; however, predrying adversely affects product quality due to skin splitting.

GREEN BEAN BLANCHING

Table 15 presents a summary of the green bean blanching results.

Table 15. SUMMARY OF GREEN BEAN BLANCHING DATA[a]

Blanching treatment[b]	Effluent generation (l./kkg)	BOD_5 (kg/kkg)	Total organic nitrogen (kg/kkg)	Total phosphorus (kg/kkg)	Product yield (%)	Solids lost as product (%)
IQB-0	163	1.0	0.03	0.008	94.0	1.16
Deep bed	125	0.55	0.015	0.005	97.3	0.89
Pipe	334	--	--	--	--	--

[a] Expressed per kkg of blanched product. See Tables A7 and A8 for complete data. All pipe blanching analyses were discarded due to inappropriate sample storage.

[b] IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.
Pipe means pipe blanching.

In green bean blanching, steam blanching resulted in a 51-63% decrease in effluent generation compared to pipe blanching. With green beans there was a different trend than with the previously blanched products. In pea, corn or lima bean blanching the deep bed steam blanching treatment always resulted in a greater generation of effluent. With green beans the opposite is true; that is, deep bed blanching resulted in less effluent than IQB-0. This reflects the peculiar nature of green bean blanching in that the maximum temperature reached was 79 C (175 F). In green bean blanching, the bean must reach at least 63 C (145 F) but must not exceed 82 C (180 F) in order to activate the enzyme pectin methyl esterase (PME). This enzyme, once activated, will cleave methoxy groups from pectin in the outer layer allowing calcium-pectin interaction and consequently no sloughing. In both deep bed and IQB the mass average temperature was between 77 C (170 F) and 82 C (180 F). Consequently there was no difference in the amount of steam required for heating. Also, since there was no difference in temperature both treatments should have resulted in equivalent surface water-holding capacity. However, in deep bed steam blanching there was a greater water-holding capacity in the bed itself resulting in less effluent draining from the process.

Ralls et al.[8] reported effluent generation of 196 l./kkg (47 gal/ton) for steam blanching and 7080 l./kkg (1700 gal/ton) for water blanching. Both of these values are considerably higher than the IQB-O and Deep Bed reported here and, in the case of steam blanching, may be due to blanching in 100 C steam rather than a steam-air mixture at 79-82 C (175-180 F). The exceedingly high value for the water blanching system may reflect the fact that batch-type experiments were conducted and perhaps much more product could have been processed before the blancher water had to be changed. Also, feed and bleed systems may be more efficient from a waste generation standpoint than straight batch systems. Soderquist et al.[10] reported 446 l./kkg (107 gal/ton) for a rotary steam blancher. This compares quite favorably to the 334 l./kkg (80 gal/ton) reported here for pipe blanching.

The BOD/N/P ratio for green bean blancher effluent was 114/3.8/1 (range 105-129/2.7-7.4/1)indicating that the liquid waste stream probably contains adequate nitrogen and phosphorus for biological treatment. Soderquist et al.[10] reported a BOD/N/P ratio of 109/6/1 for the rotary blanching operation and a BOD/COD ratio of 0.53.

Predrying was not attempted in this study since results in 1971[5] had shown that even with a 6% weight reduction skin rupture was severe. With predrying to less than 6%, the savings in effluent generation would not justify the cost of predrying. Therefore, predrying prior to IQB is not recommended for green beans.

Table 16 summarizes the objective evaluations performed on green beans. Can vacuum was noticeably lower for the two steam blanched samples compared to pipe blanched samples. This was probably due to brine overfill in the experimentally blanched samples since the can vacuum values do not follow any pattern with storage time. If the poor can vacuum had been due to presence of air cells in the green bean tissue, the can vacuum values would have decreased upon storage. Instead the can vacuum actually increased upon storage for the IQB sample and fluctuated for the deep bed sample. There was no significant difference in drained weight between any of the treatments. For slough and percent splits, however, IQB was definitely superior to both deep bed steam blanching and pipe blanching. These low values are indicative that PME had been activated. With deep bed steam blanching the surface temperature of the tissue may have been over 180 F for short periods of time resulting in PME inactivation. Deep bed steam blanching compares favorably to pipe blanching.

Subjective evaluation of green beans is summarized in Table 17. From these data it is apparent that there is no real preference for product blanched in steam or hot water. Even though the objective tests indicated considerably less slough and percent splits for IQB, the taste panel could not pick out that characteristic as a basis for establishing preference. This points out the fallacy of using only objective or subjective tests to evaluate innovative or new processing techniques.

In conclusion, IQB and deep bed steam blanching can be used to blanch green beans prior to canning. A steam-air mixture at 77-82 C (170-180 F) is required to activate PME. IQB produced 51 percent

Table 16. SUMMARY OF OBJECTIVE EVALUATION OF GREEN BEANS[a]

	Can Vacuum (cm. Hg. vacuum)							
	Months of Storage							
	1		3		6		9	
Blanching treatment	Aver.	Range	Aver.	Range	Aver.	Range	Aver.	Range
IQB	1.0	0-5.1	0.0	0-0	3.1	0-7.6	4.1	0-8.9
Deep Bed	0.8	0-1.3	6.9	2.5-12.7	1.5	0-7.6	8.9	5.1-14.0
Pipe	17.0	15.2-17.8	16.3	12.7-19.1	17.0	16.5-17.8	17.0	16.5-19.1
	Drained Weight (g)							
IQB	264.1	262.8-265.2	266.6	260.6-272.2	270.5	266.2-272.8	269.3	268.4-270.5
Deep Bed	274.3	272.4-275.6	275.8	273.2-279.1	275.6	273.8-276.6	279.8	278.8-281.3
Pipe	276.3	265.7-282.8	241.6	240.9-242.7	287.1	283.8-293.0	293.5	292.9-294.2
	Slough (%)							
IQB	4.0	3.0-5.0	8.0	8.0-8.0	7.0	7.0-7.0	10.0	9.0-11.0
Deep Bed	13.5	12.0-15.0	16.0	14.0-18.0	16.0	15.0-17.0	15.0	15.0-15.0
Pipe	7.8	6.5-9.0	16.0	16.0-16.0	11.0	9.0-13.0	15.0	14.0-16.0
	Splits (%)							
IQB	5.0	5.0-5.0	2.5	0-5.0	5.0	5.0-5.0	15.0	10.0-20.0
Deep Bed	32.5	30.0-35.0	30.0	25.0-35.0	35.0	30.0-40.0	22.5	20.0-25.0
Pipe	52.5	35.0-70.0	55.0	50.0-60.0	22.5	20.0-25.0	55.0	55.0-55.0

[a] Each average consists of at least three observations.

less effluent than pipe blanching and resulted in considerably less slough and percent splits. Organoleptically, the steam blanched products were quite acceptable.

Table 17. SUMMARY OF SUBJECTIVE EVALUATION OF GREEN BEANS

Blanching treatment[a]	Storage time[b] (months) 1	3	6	9
IQB-0	0.1% 10-5-5	5% 6-3-4	NS	5% 6-6-4
Deep bed	NS	1% 5-6-3	1% 5-8-3	1% 5-6-6

[a] IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.

[b] Each sample was compared to a pipe-blanched, canned control. The control was canned the same day as the experimental sample. The top number is the level of significance and the bottom three numbers represent number of judges preferring experimental sample, control and no preference, respectively. NS means no significant difference.

POTATO BLANCHING

Potato blanching data are summarized in Table 18.

Table 18. SUMMARY OF POTATO BLANCHING DATA[a]

Blanching treatment[b]	Effluent generation (l./kkg)	BOD_5 (kg/kkg)	Total organic nitrogen (kg/kkg)	Total phosphorus (kg/kkg)	Product yield (%)	Solids lost as product (%)
IQB-6.9	100	0.5	0.03	0.0085	93.1	0.43
IQB-0	171	0.75	0.05	0.012	93.4	0.60
Deep bed	167	0.65	0.065	0.017	93.8	0.61

[a] Expressed per kkg of blanched product. See Tables A9 and A10 for complete data.

[b] IQB-6.9 means IQB with a 6.9% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.

Since potatoes are not normally blanched following slicing or dicing there is no water blanching method to which to compare the steam blanching method. However, these experiments were included for those processors who both can and freeze or dehydrate potatoes. Prior to freezing or dehydration, potatoes may be blanched. The data for effluent generation are quite similar to those presented for corn and reflect the water-holding capacity of the cut potato surface. The BOD_5 generated per ton of product is quite low suggesting that most of the free surface cellular juices were washed off the potato prior to blanching. This prewashing was accomplished by transporting the potatoes to the laboratory under water and then washing them again in the pilot plant. Deep bed and IQB-0 resulted in nearly the same effluent generation. This was due to the fact that peroxidase inactivation in the potato slice required a heat time of 60 seconds resulting in a mass average temperature near 93 C (200 F). Thus, compared to deep bed steam blanching where the mass average temperature was between 93-99 C (200-210 F), there would be little difference in the total steam condensed. Consequently, there was little difference between deep bed and IQB. The heat only section of the IQB process was not run with potatoes or any of the root crops. This was not run since it had been observed in earlier trials that IQB-0 and the heat-only runs did not differ significantly in effluent generation since little effluent was released in the hold section. Also, for the root crops blanching is usually required prior to freezing to partially cook the product. Under these circumstances the heat-only method would probably not be adequate as a blanching technique.

The BOD/N/P ratio for potato blancher effluent was 57/3.9/1 (range 37-66/3.6-4.2/1) indicating that adeuqate nutrients are available for biological treatment. The BOD/COD ratio averaged 0.90.

Objective analysis of the potato blanching trials is summarized in Table 19. The lower can vacuum for the steam blanched samples is attributed to overfill rather than incomplete tissue gas removal.

Table 19. SUMMARY OF OBJECTIVE EVALUATION OF POTATOES[a]

	Can Vacuum (cm. Hg. vacuum)							
	Months of Storage							
	1		3		6		9	
Blanching treatment[b]	Aver.	Range	Aver.	Range	Aver.	Range	Aver.	Range
IQB-6.9	12.2	8.9-16.5	7.9	5.1-10.2	10.9	7.6-15.2	12.2	8.9-16.5
IQB	12.4	10.2-19.1	7.8	5.1-11.4	12.7	7.6-17.8	10.9	7.6-15.2
Deep Bed	9.4	3.8-11.4	8.6	6.4-12.7	11.7	10.2-17.8	16.0	14.0-19.1
Control	22.4	16.5-27.9	17.3	14.0-25.4	18.5	12.7-24.1	20.6	15.2-25.4
	Drained Weight (g)							
IQB-6.9	334.6	332.2-335.0	330.6	326.1-333.8	338.2	331.4-342.9	333.1	328.6-336.8
IQB	343.6	335.0-352.9	330.9	320.7-335.7	336.3	328.8-340.4	336.0	325.3-343.9
Deep Bed	345.1	334.4-352.8	244.9	328.4-356.2	340.5	328.3-358.1	337.4	330.4-343.7
Control	312.4	285.7-335.4	286.6	274.2-301.3	311.3	292.6-350.8	308.4	283.1-357.1

[a] Each average consists of at least three observations.

[b] Control samples were not blanched prior to canning. The whole potato was treated in hot water and steam before peeling.

The higher drained weights for the steam blanched samples show an overfill of about 28 g. (one ounce). Thus, instead of filling at a 312 g. (11 ounce) fill weight, a 284 g. (10 ounce) fill weight would be sufficient.

Table 20 presents a summary of the subjective evaluations on potatoes. The IQB predried blanching technique was not acceptable due to darkening of the potato surface during air drying. This is evidenced by the low preference for the IQB-predried sample. With IQB and deep bed steam

Table 20. SUMMARY OF SUBJECTIVE EVALUATION OF POTATOES

Blanching treatment[a]	Storage time[b] (months) 1	3	6	9
IQB-6.9	5% 2-9-3	0.1% 4-6-8	1% 5-5-6	NS
IQB-0	NS	NS	NS	1% 4-8-5
Deep bed	0.1% 4-9-3	NS	NS	1% 8-5-2

[a] IQB-6.9 means IQB with a 6.9% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.

[b] Each sample was compared to a control sample. The control was canned the same day as the experimental sample. The top number is the level of significance and the bottom three numbers represent number of judges preferring experimental sample, control and no preference, respectively. NS means no significant difference.

blanching there was very little difference in samples as evidenced by the taste panel results. However, when the products were compared in large quantity batches (for example, a can full), the steam blanched product appeared somewhat darker than the pipe blanched. This was believed due to darkening of the potatoes in transport to the laboratory. The importance of this slight darkening is not readily apparent since the taste panel showed no preference.

In conclusion, IQB without predrying can be successfully applied to potato blanching. At the loading rates used in this study, IQB offered little advantage over deep bed steam blanching. However, at greater loading rates IQB would be expected to produce significantly less effluent than deep bed steam blanching. The IQB blanched product was equivalent to conventionally canned product. Predrying is not recommended due to surface darkening during air dehydration.

BEET BLANCHING

The beet blanching data are summarized in Table 21.

Table 21. SUMMARY OF BEET BLANCHING DATA[a]

Blanching treatment[b]	Effluent generation (l./kkg)	BOD$_5$ (kg/kkg)	Total organic nitrogen (kg/kkg)	Total phosphorus (kg/kkg)	Product yield (%)	Solids lost as product (%)
IQB-5.6	196	5.75	0.11	0.0285	86.3	5.21
IQB-0	229	4.95	0.085	0.022	89.4	4.02
Deep bed	225	4.8	0.11	0.0305	88.9	5.26

[a] Expressed per kkg of blanched product. See Tables A11 and A12 for complete data.

[b] IQB-5.6 means IQB with a 5.6% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.

As with potatoes sliced beets are not normally blanched prior to canning and, therefore, there is no conventional blanching operation for comparison. Generally it is assumed that blanching will be accomplished in the steam treatment and/or hot water process just prior to peeling. Frequently, however, the center temperature of the beet is not in the range to inactivate enzymes. When this is the case, delay in getting the sliced or diced beets in the can may result in darkening of the beet. This is undesirable. The beet slices that were obtained from the canning plant for this study had positive peroxidase activity prior to the steam blanching runs.

The data in Table 21 reveal several important characteristics of beet blanching. First, the effluent generation values are nearly the same as those reported for pea blanching. The high effluent generation values, however, are the result of cellular losses rather than inability of the beet surface to hold surface moisture. The BOD values are the highest of those reported in this study as are the "solids lost as product" figures. This indicates that beet tissue is very susceptible to heat damage. Consequently, any method of blanching will result in high solids loss from the tissue. For comparison, Ralls et al.[8] reported 317 l./kg (76 gal/ton) for steam blanching of beets and 5550 l./kkg (1330 gal/ton) for water blanching. Comparing IQB to those results, IQB would reduce liquid waste generation by about 28%. As with green beans, the 5550 l./kkg (1330 gal/ton) is probably unduly large since presumably more product could have been run through the blancher, lowering the effluent value. Predrying the beet surface prior to IQB resulted in a further decrease in effluent generation; however, during air drying some darkening did occur. This was undesirable and resulted in a low preference for that treatment.

The BOD/N/P ratio averaged 208/3.8/1 (range 158-292/3.6-4.0/1) indicating that beet blancher water maybe low in nitrogen for biological waste treatment. The BOD/COD ratio averaged 0.97 slightly higher than the 0.87 reported by Soderquist et al.[10].

Objective evaluation of beets resulted in the data summarized in Table 22. The can vacuum was lower for all the steam blanched samples compared to control. Examination of the drained weight data shows that the experimental samples contained at least 56 g. (two ounces) more than the control and were overfilled. Instead of using the 312 g. (11 ounce) fill weight, the fill weight could have been 256 g. (9 ounces). The drained weight data show that in the can the beet will lose tissue juices during the retorting operation and consequently the drained weight is less than the fill weight. By blanching prior to canning the juice is lost before the beet is put in the can. From a canner's point of view it is best not to blanch prior to canning since then he has to clean up the blancher effluent. Without blanching, the effluent ends up in the can and eventually ends up in the kitchen where the housewife disposes of it. On the other hand, if the canner has difficulty making drained weight on canned beets, then blanching prior to canning will allow him to more nearly match fill weight to drain weight.

Table 22. SUMMARY OF OBJECTIVE EVALUATION OF BEETS[a]

	Can Vacuum (cm. Hg. vacuum)							
	Months of Storage							
	1		3		6		9	
Blanching treatment[b]	Aver.	Range	Aver.	Range	Aver.	Range	Aver.	Range
IQB-5.6	10.4	8.9-11.4	7.9	5.1-15.2	8.6	5.1-10.2	5.8	5.1-8.9
IQB	11.9	7.6-15.2	6.4	5.1-7.6	4.6	2.5-5.1	7.6	5.1-10.2
Deep Bed	10.4	6.4-12.7	5.1	5.1-5.1	6.1	2.5-10.2	12.4	7.6-15.2
Control	22.9	16.5-33.0	16.3	10.2-22.9	15.0	11.4-19.1	16.8	10.2-20.3
	Drained Weight (g)							
IQB-5.6	330.3	327.2-331.4	329.7	326.6-330.8	329.2	327.6-330.8	332.8	329.8-334.9
IQB	327.5	323.4-332.3	325.7	320.3-328.2	332.3	328.3-338.0	329.4	323.1-337.8
Deep Bed	326.3	323.8-327.0	329.2	320.8-332.7	336.3	328.3-340.0	332.8	325.1-339.1
Control	265.5	249.7-281.0	262.1	240.5-279.0	250.2	218.0-266.5	259.6	244.1-288.5

[a] Each average consists of at least three observations

[b] Control samples were not blanched prior to canning. The whole beet was treated in hot water and steam before peeling.

Table 23 presents a summary of the subjective evaluations of beets. The predried beets were definitely of poorer quality than the control, the primary difference being the darker color of the predried samples. For the other steam blanching methods no consistent difference was found.

Table 23. SUMMARY OF SUBJECTIVE EVALUATION OF BEETS

Blanching treatment[a]	Storage time[b] (months) 1	3	6	9
IQB-5.6	1% 4-7-4	NS	1% 3-7-4	0.1% 4-7-11
IQB	NS	NS	NS	NS
Deep bed	1% 6-6-4	NS	0.1% 2-15-1	NS

[a] IQB-5.6 means IQB with a 5.6% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.

[b] Each sample was compared to a control sample. The control was canned the same day as the experimental sample. The top number is the level of significance and the bottom three numbers represent number of judges preferring experimental sample, control and no preference, respectively. NS means no significant difference.

In conclusion, IQB without predrying is an effective way of blanching beets with reduced effluent generation. Beet tissue is extremely sensitive to high temperatures resulting in loss of tissue juice. Predrying reduces effluent further; however, product quality is adversely affected. Blanching prior to canning would be an effective way to insure meeting drained weights for beets.

CARROTS

Carrot blanching data are summarized in Table 24. Carrots, like other root crops, beets and potatoes, are not normally blanched after slicing or dicing unless they are to be frozen or dehydrated. Therefore, there was no commercial blanching operation to monitor in this study. Even though the whole carrot receives a hot water and steam treatment prior to peeling, peroxidase activity was still present in the sliced carrots. The values in Table 24 for effluent

Table 24. SUMMARY OF CARROT BLANCHING DATA[a]

Blanching treatment[b]	Effluent generation (l./kkg)	BOD_5 (kg/kkg)	Total organic nitrogen (kg/kkg)	Total phosphorus (kg/kkg)	Product yield (%)	Solids lost as product (%)
IQB-0	192	2.0	0.10	0.016	91.8	1.93
Deep bed	225	2.6	0.14	0.023	88.4	2.77

[a] Expressed per kkg of blanched product. See Tables A13 and A14 for complete data.

[b] IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.

generated are similar to the others reported in this study. Predrying would be expected to reduce blancher effluent even further. In the original studies by Lazar et al.[3] carrots predried to a 5.8% weight reduction produced only half as much effluent as IQB without predrying. The product yield values reported here indicated that the carrot surface loses some of its moisture-holding capacity as the surface temperature is increased since the losses are in excess of those calculated from solids loss. The BOD/N/P ratio averaged 122/6.3/1 (range 117-126/6.1-6.7/1) indicating that carrot blancher effluent has adequate nutrients for biological waste treatment. The BOD/COD ratio was 0.87.

Table 25 presents the results on the objective evaluation of carrots. There was no significant difference in either the can vacuum or drained weights when steam blanched samples were compared to control samples.

Subjective evaluation results for carrots are shown in Table 26. The preference of the taste panel for the control sample is markedly evident in these data. This serves to illustrate the importance of

Table 25. SUMMARY OF OBJECTIVE EVALUATION OF CARROTS [a]

Blanching treatment[b]	Can Vacuum (cm. Hg. vacuum) Months of Storage 1 Aver.	1 Range	3 Aver.	3 Range	6 Aver.	6 Range	9 Aver.	9 Range
IQB	9.1	7.6-11.4	7.9	7.6-8.9	9.9	5.1-16.5	13.7	12.7-15.2
Deep bed	11.7	8.9-15.2	10.9	7.6-12.7	8.1	2.5-15.2	14.0	12.7-15.2
Control	9.1	7.6-11.4	7.1	3.8-8.9	7.9	2.5-12.7	10.9	10.2-12.7
	Drained Weight (g)							
IQB	284.0	280.1-285.5	286.6	284.0-288.8	284.3	281.4-287.9	283.1	278.1-286.6
Deep bed	293.9	291.1-295.4	292.5	290.7-293.4	290.5	285.9-293.2	293.7	291.5-295.2
Control	267.5	259.4-274.7	265.5	262.5-277.7	280.6	272.4-292.2	278.3	273.0-284.8

[a] Each average consisted of three observations.

[b] Control samples were not blanched prior to canning. The whole carrot was treated in hot water and steam before peeling.

Table 26. SUMMARY OF SUBJECTIVE EVALUATION OF CARROTS

Blanching treatment[a]	Storage time[b] (months) 1	3	6	9
IQB	0.1% 0-11-5	0.1% 6-13-7	0.1% 5-12-3	0.1% 1-9-10
Deep bed	0.1% 2-11-7	0.1% 5-10-6	0.1% 4-11-5	0.1% 2-8-10

[a] IQB means IQB without predrying.
Deep bed means deep bed steam blanching.

[b] Each sample was compared to a control sample. The control was canned the same day as the experimental sample. The top number is the level of significance and the bottom three numbers represent number of judges preferring experimental sample, control and no preference, respectively.

color in product evaluation. The steam blanched carrots were transported to the laboratory and there was considerable darkening of the tissue even though it was held under water. The taste panel preferred the brighter orange color of the control. In the study by Lazar et al.[3] IQB samples were judged to be better than the conventionally steam blanched product. In the opinion of most of the judges the only difference between samples in the present study was color.

In conclusion, IQB can be used to blanch carrots prior to canning, freezing or dehydration. There was no adverse effects of the steam blanching treatment on carrots prior to canning. Blanching of carrots prior to canning could be recommended if there are unduly long delays between cutting and can filling. During this delay color changes could occur.

LOADING RATE AND SIZE OF COMMERCIAL IQB UNITS

One of the basic principles inherent in IQB is that each piece of vegetable receives the same thermal energy as every other piece. If there is some condition which alters exposure time or rate of heat transfer to the surface of the vegetable, then there is the possibility of underblanching. In heat transfer the total quantity of heat transferred is directly proportional to the exposed surface area. Loading conditions which will decrease total surface exposed may result in underprocessing and therefore belt loading rate is an extremely important variable in the IQB process.

The belt loading rates for the heat belt, hold belt and deep bed steam heating belt were calculated based on through-put, residence time and belt dimensions. The results for each run are given in the Appendix.

To summarize the data, the following observations can be made: 1) Heat belt loading--for the IQB process the heat belt was loaded at approximately 4.9 kg/m^2 (1 lb./ft^2). For these products this would be optimal loading for exposing each piece to the steam conditions in the heat section. This loading was recommended in previous publications on IQB[3]. For beets and carrots, belt loadings were somewhat higher, generally 6.3 to 9.8 kg/m^2 (1.3 to 2.0 lb./ft^2). With these two products higher product loading rates could be used since medium slices (3.2-4.4 cm. diameter by 0.64 cm. thick) did not pack and reduce heat transfer surface area as much as other product forms (i.e. peas, corn, lima beans, or green beans). With deep bed blanching, loading rate was limited by configuration of the equipment. The deep bed was 5.1 to 6.4 cm. (2 to 2.5 inches) deep resulting in different loading rates depending on product geometry: peas--12.9 kg/m^2 (2.65 lb/ft^2); corn--14.5 kg/m^2 (2.98 lb/ft^2); lima beans--14.8 kg/m^2 (3.04 lb/ft^2); green beans--7.03 kg/m^2 (1.44 lb/ft^2); potatoes--11.8 kg/m^2 (2.41 lb/ft^2); beets--16.4 kg/m^2 (3.36 lb/ft^2) and carrots--16.0 kg/m^2 (3.28 lb/ft^2). Green beans had the lowest product density in the deep bed. This would be expected since cylinders with a length to diameter ratio of 3:1 have a very low packing density. 2) Hold belt loadings--in the IQB process hold belt loadings varied from 17.6 kg/m^2 (3.6 lb/ft^2) for potatoes to 69.3 kg/m^2 (14.2 lb/ft^2) for green beans. Hold section belt loading reflects the compounding effect of many variables including ratio of heat residence time to hold residence time, ratio of heat belt width to hold belt width, and ratio of heat section length to hold section length. For our system the heat and hold belts were nearly the same width [21.6 cm (8.5 inch) wide heat belt; 20.3 cm (8.0 inch) wide hold belt] and the length ratio was 3/1 [i.e. 91.4 cm (3 ft) heat section/30.5 cm (1 ft) hold section]. The ratio of heat belt loading to hold belt loading should, under these conditions, be equal to the ratio of the lineal velocity of the hold belt to the lineal velocity of the heat belt.

$$\left(\frac{\text{loading rate heat belt}}{\text{loading rate hold belt}}\right) = \left(\frac{\text{lineal velocity hold belt}}{\text{lineal velocity heat belt}}\right)$$

The lineal velocity is the length of the belt divided by the residence time in the section and since L(Heat)/L(Hold) = 3/1, the loading rate on the heat belt/loading rate on the hold belt is:

$$\frac{(\text{Loading rate})_{\text{Heat}}}{(\text{Loading rate})_{\text{Hold}}} = \left(\frac{1}{3}\right)\frac{\text{residence time in heat section}}{\text{residence time in hold section}}$$

or

$$\frac{(\text{L.R.})_{\text{Heat}}}{(\text{L.R.})_{\text{Hold}}} = \left(\frac{1}{3}\right)\frac{\tau\ \text{Heat}}{\tau\ \text{Hold}}$$

where L.R. = loading rate, kg/m^2

and τ = residence time, seconds.

Using heat/hold times reported in this study, the size of a commercial belt-type IQB unit was calculated and is given in Table 27. A heat belt loading rate of 4.9 kg/m^2 (1 lb/ft^2) and a hold belt loading rate of 49 kg/m^2 (10 lb/ft^2) was assumed. Blanch times are the same as those reported in Table 3. For commercial units it would be expected that costs for an IQB blancher of this configuration would not be more than that for rotary-type water blanchers of comparable production capacity. Compared to conventional steam blanchers, IQB would be less costly since the IQB unit is considerably shorter for the same production capacity.

Regarding developments of hardware for IQB units, the engineering research team at Western Regional Research Laboratory, USDA, Berkeley, recently reported[11] on the development of a prototype IQB unit using spiral vibrating conveyors. High production rates, compactness, simplicity and control of residence time were claimed for the unit. A larger prototype is planned for construction.

Table 27. ESTIMATED IQB PRODUCTION UNITS[a]

Product	Production rate	
	(kkg product/hr)	(tons product/hr)
Peas	9.1	10
Corn	13.6	15
Lima beans	13.6	15
Green beans	13.6	15
Potatoes	4.5	5
Carrots	5.7	6.3
Beets	5.7	6.3

[a] Heat 1.52 m (5 ft) wide x 9.14 m (30 ft) long loaded at 4.9 kg/m^2 (1 lb/ft^2).

Hold 1.52 m (5 ft) wide x 1.37 m (4.5 ft) long loaded at 49 kg/m^2 (10 lb/ft^2).

SECTION VII

UNITS FOR INTERCONVERSION OF DATA

To aid in the interconversion and increased digestibility of data contained in this report, several important conversion factors are presented in the following table:

Table 28. FACTORS FOR INTERCONVERSION OF DATA

To convert from:	To:	Multiply by:
cm	ft.	0.0328
g	ounces	0.0353
kkg	ton	1.103
kg/m^2	lb/ft^2	0.205
cm	in.	0.394
l./kkg	gal/ton	0.240
kg/kkg	lb/ton	2.00
l./hr	gal/hr	0.264
l./case	gal/case	0.264

All of the values contained in this report based on the amount of product were calculated based on the amount of product (kkg or ton) processed. It is frequently desirable to know effluent generation based on plant input rather than plant output. Therefore, to facilitate these calculations the following are given:

Table 29. CANNING YIELD FACTORS

Product	Pounds product[a] / case	Cases[b] / ton raw product	Ton raw product / ton processed product
Peas	15.5	115	1.13
Corn	15.75	32	3.97
Lima beans	13.5	130	1.14
Green beans	13.5	125	1.19
Potatoes	16.5	75	1.62
Beets	16.5	70	1.73
Carrots	14.6	65	2.10

[a] Calculated based on fill weight.

[b] Reference 12.

SECTION VIII

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SECTION IX

LIST OF PUBLICATIONS

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2. Lund, D. B. Impact of the Individual Quick Blanch (IQB) Process on Cannery Waste Generation. Presented at the Fourth National Symposium on Food Processing Wastes, Syracuse, New York, April 1973.
3. Lenz, M. K. and D. B. Lund. Lethality Calculations for Heat/Cool Processes by the L-Fo Method. Submitted to J. Food Science, 1973.

Section X

Appendix - Raw Data

Table A1. INDIVIDUAL BLANCHING TRIALS FOR PEAS

Blanching[a] treatment	Treatment number	Belt loading		Effluent generation (l./case)	Product yield (%)	Solids lost as product (%)
		Heat (kg/m^2)	Hold (kg/m^2)			
IQB-6.25-4-Als	1P	5.08	24.20	1.09	88.8	1.37
IQB-0-4-Als	2P	5.42	25.82	1.76	87.5	1.57
30 Sec-4-Als	3P	5.42	--	1.51	90.0	2.10
Deep bed-4-Als	4P	13.13	--	2.15	83.8	3.31
IQB-7.0-3-Ala	5P	4.49	21.52	0.913	90.0	1.14
IQB-0-3-Ala	6P	4.39	20.94	1.47	90.5	2.51
30 Sec-3-Ala	7P	4.20	--	1.39	91.3	1.85
Deep bed-3-Ala	8P	13.52	--	2.15	83.8	2.77
IQB-7.5-Perf.	9P	5.42	25.91	1.10	87.5	2.10
IQB-0-Perf.	10P	5.86	28.01	1.51	90.0	2.12
30 Sec-Perf.	11P	5.22	--	1.51	90.0	2.33
Deep bed-Perf.	12P	12.20	--	2.29	82.5	3.26
Averages						
IQB-6.9		5.00	23.86	1.04	88.8	1.53
IQB-0		5.22	24.94	1.58	89.3	2.07
30 Sec		4.93	--	1.47	90.4	2.09
Deep bed		12.93	--	2.19	83.3	3.11

[a] IQB-6.25 means IQB with a 6.25% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
30 sec means heat only stage of IQB.
Deep bed means deep bed steam blanching.
4 or 3 refers to sieve size; perfection was sieve size 3, 4 and 5.
Als means Alsweet; Ala means Alaskan; Perf. means Perfection.

Table A2. CHARACTERISTICS OF EFFLUENTS GENERATED DURING PEA BLANCHING

Treatment[a] number	BOD_5 (ppm)	Total solids (%)	Total phosphorus (ppm)	Total organic nitrogen (ppm)
1P	9730	1.99	82	414
2P	7260	1.43	77	294
3P	11300	2.16	107	485
4P	13200	2.58	113	596
5P	10300	1.94	164	548
6P	15800	2.66	215	768
7P	10500	2.04	167	612
8P	13400	2.16	174	678
9P	15600	3.06	195	893
10P	11400	2.18	154	684
11P	13600	2.40	162	747
12P	14200	2.44	189	824
Pipe	8300	1.54	150	463
Pipe	7500	1.42	105	433
Averages				
IQB-6.9	11900	2.33	147	618
IQB-0	11500	2.09	149	582
30 Sec	11800	2.20	145	615
Deep bed	13600	2.39	159	699
Pipe	7900	1.48	128	448

Table A2 (continued). CHARACTERISTICS OF EFFLUENTS GENERATED DURING PEA BLANCHING

Treatment number	Volatile solids (ppm)	Suspended volatile solids (ppm)	Suspended solids (%)	Soluble phosphorus (ppm)	Nitrogen			pH
					NH_3 (ppm)	NO_3 NO_2 (ppm)	NO_2[b] (ppm)	
1P	18000	644	.066	37	20	1.0	--	7.0
2P	13000	476	.055	30	15	0.7	--	7.0
3P	19600	595	.069	46	19	0.6	--	7.0
4P	23500	581	.070	55	27	0.6	--	7.0
5P	17300	329	.034	75	24	0.9	.16	6.6
6P	23400	547	.058	113	28	0.8	.08	6.9
7P	18200	473	.052	102	16	0.6	.05	6.9
8P	19200	389	.050	99	22	0.6	.05	6.9
9P	27100	2170	.224	101	37	0.6	--	6.8
10P	19200	1120	.119	84	32	0.7	--	7.0
11P	21200	1230	.132	94	32	0.6	--	6.9
12P	21600	991	.108	91	37	1.0	--	6.9
Pipe	13400	200	.025	77	25	0.6	.09	7.7
Pipe	12200	775	.087	52	36	0.9	--	7.3
Averages								
IQB-6.9	20800	1050	.108	71	27	0.8	.16	6.8
IQB-0	18500	713	.077	76	25	0.7	.08	7.0
30 Sec	19700	765	.084	81	23	0.6	.05	6.9
Deep bed	21400	654	.076	82	29	0.7	.05	6.9
Pipe	12800	488	.056	65	31	0.8	.09	7.5

[a] See footnote and treatment number on Table A1. Pipe means pipe blanching.

[b] No value indicates too small to be measured.

Table A3. INDIVIDUAL BLANCHING TRIALS FOR CORN

Blanching treatment[a]	Treatment number	Belt loading Heat (kg/m^2)	Belt loading Hold (kg/m^2)	Effluent generation (l./case)	Product yield (%)	Solids lost as product (%)
IQB-7.5	1C	4.73	22.59	.489	94.7	.50
IQB-0	2C	4.39	20.94	.978	96.3	1.43
20 Sec	3C	4.39	--	.822	98.1	1.00
Deep bed	4C	12.40	--	1.17	94.1	1.90
IQB-7.5	5C	5.66	27.08	.644	92.8	1.14
IQB-0	6C	3.81	18.30	.921	96.9	1.75
20 Sec	7C	4.39	--	1.00	95.9	1.87
Deep bed	8C	16.40	--	1.20	93.8	3.19
IQB-7.5	9C	6.30	30.11	.728	91.9	.79
IQB-0	10C	5.12	24.40	.819	98.1	1.66
20 Sec	11C	5.12	--	.826	98.1	1.68
Deep bed	12C	14.84	--	1.11	94.9	2.17
Averages						
IQB-7.5		5.56	26.60	6.22	93.1	.81
IQB-0		4.44	21.23	.906	97.1	1.61
20 Sec		4.64	--	.883	97.4	1.52
Deep bed		14.54	--	1.16	94.2	2.42

[a] IQB-7.5 means IQB with 7.5% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
20 sec means heat only stage of IQB.
Deep bed means deep bed steam blanching.

Table A4. CHARACTERISTICS OF EFFLUENTS GENERATED DURING CORN BLANCHING

Treatment number[a]	BOD_5 (ppm)	COD (ppm)	Total solids (%)	Total phosphorus (ppm)	Total organic nitrogen (ppm)
1C	10400	--	1.94	104	177
2C	14000	--	2.71	159	296
3C	12500	--	2.23	135	231
4C	16600	--	3.10	170	260
5C	24900	29900	3.38	105	211
6C	22700	32400	3.50	132	255
7C	28300	33400	3.48	142	256
8C	37800	51900	5.09	189	322
9C	13800	23300	2.13	87	196
10C	26500	34200	3.68	172	368
11C	31000	34500	3.72	169	398
12C	26800	30700	3.69	154	318
Pipe	3000	--	.455	30	68
Pipe	6500	--	.884	40	100
Pipe	11000	--	1.61	72	208
Averages					
IQB-7.5	16400	26600	2.48	99	195
IQB-0	21000	33300	3.30	154	306
20 Sec	23900	34000	3.14	149	295
Deep bed	27000	41300	3.96	171	300
Pipe	6800	--	.983	47	125

Table A4 (continued). CHARACTERISTICS OF EFFLUENTS GENERATED DURING CORN BLANCHING

Treatment number	Volatile solids (ppm)	Suspended volatile solids (ppm)	Suspended solids (%)	Soluble phosphorus (ppm)	Nitrogen			pH
					NH_3 (ppm)	NO_3[b] NO_2 (ppm)	NO_2[d] (ppm)	
1C	18300	1240	.136	50	7		--	6.5
2C	25600	1700	.179	89	5		--	6.4
3C	20900	3010	.307	86	4		--	6.8
4C	29100	712	.076	98	8		--	6.8
5C	32400	1780	.187	101	22		.02	7.0
6C	33500	6390	.639	106	13		.03	7.0
7C	33300	8660	.880	114	13		.03	6.9
8C	48900	2460	.247	151	25		Trace	6.9
9C	20500	1360	.136	17	11		Inter	7.0
10C	35300	13400	(1.344)[c]	38	14		Inter	6.9
11C	35900	4710	.471	37	13		Inter	7.0
12C	34200	2060	.206	24	16		Inter	7.2
Pipe	3970	215	.022	15	2		--	7.5
Pipe	8250	460	.047	30	7		.10	7.9
Pipe	15200	1120	.112	18	7		Inter	6.9
Averages								
IQB-7.5	23700	1460	.153	56	13		.02	6.8
IQB-0	31500	7170	.409[c]	78	11		.03	6.8
20 Sec	30000	5460	.553	79	10		.03	6.9
Deep bed	37400	1750	.176	91	17		Trace	7.0
Pipe	9140	600	.060	21	5		.10	7.4

[a] See footnote and treatment number on Table A3.

[b] Interference on all NO_3-N determinations.

[c] The 1.344 value was not used in the average since it was higher than corresponding values by factor of 10.

[d] No value means too small to be measured.
Inter means interference.

Table A5. INDIVIDUAL BLANCHING TRIALS FOR LIMA BEANS

Blanching treatment[a]	Treatment number	Belt loading		Effluent generation (1./case)	Product yield (%)	Solids lost as product (%)
		Heat (kg/m^2)	Hold (kg/m^2)			
IQB-5.0	1LB	4.83	61.78	.406	97.5	.24
IQB-0	2LB	5.76	73.15	.879	95.6	.63
20 Sec	3LB	6.10	--	.750	97.5	.34
Deep bed	4LB	15.32	--	1.00	94.1	.84
IQB-0	5LB	4.39	55.79	1.22	91.3	1.10
20 Sec	6LB	5.12	--	.860	95.9	.75
Deep bed	7LB	14.35	--	1.91	83.4	1.93
Averages						
IQB-5		4.83	61.78	.406	97.5	.24
IQB-0		5.08	64.46	1.05	93.4	.86
20 Sec		5.61	--	.807	96.7	.54
Deep bed		14.84	--	1.46	88.7	1.38

[a] IQB-5.0 means IQB with a 5.0% weight reduction prior to blanching.
IQB-0 means IQB without predrying.
20 sec means heat only stage of IQB.
Deep bed means deep bed steam blanching.

Table A6. CHARACTERISTICS OF EFFLUENTS GENERATED DURING LIMA BEAN BLANCHING

Treatment[a] number	BOD_5 (ppm)	COD (ppm)	Total solids (%)	Total phosphorus (ppm)	Total organic nitrogen (ppm)
1LB	5220	7790	1.20	53	341
2LB	6170	11900	1.48	71	557
3LB	5810	6750	0.91	47	318
4LB	12800	13800	1.77	100	495
5LB	13700	17600	1.96	160	864
6LB	29900	12800	1.80	146	560
7LB	16300	21200	2.42	225	879
Pipe	1200	--	.20	38	42
Pipe	770	--	.13	8	26
Pipe	400	--	.10	6	27
Pipe	400	--	.10	6	28
Averages					
IQB-5.0	5220	7790	1.20	53	341
IQB-0	9930	14800	1.72	116	711
20 Sec	17800	9780	1.36	97	439
Deep bed	14500	17500	2.10	163	687
Pipe	693	--	.13	15	31

Table A6 (continued). CHARACTERISTICS OF EFFLUENTS GENERATED DURING LIMA BEAN BLANCHING

Treatment number	Volatile solids (ppm)	Suspended volatile solids (ppm)	Suspended solids (%)	Soluble phosphorus (ppm)	Nitrogen			pH
					NH_3 (ppm)	NO_3^b NO_2 (ppm)	NO_2^b (ppm)	
1LB	9830	606	.060	35	6	4.5	.07	6.8
2LB	12300	2320	.240	40	9	4.1	.05	6.7
3LB	7470	1370	.154	27	7	3.2	.05	6.8
4LB	14500	2250	.228	43	16	3.1	.02	6.4
5LB	14100	2520	.263	9	20	Inter	Inter	6.5
6LB	15200	1660	.182	8	17	Inter	Inter	6.6
7LB	19600	2650	.282	10	13	Inter	Inter	6.5
Pipe	1390	125	.014	13	2	2.7	.02	8.5
Pipe	850	65	.010	2	1	2.5	.02	8.6
Pipe	625	25	.004	1	2	Inter	Inter	7.9
Pipe	660	30	.005	1	1	Inter	Inter	7.6
Averages								
IQB-5.0	9830	606	.060	35	6	4.5	.07	6.8
IQB-0	13200	2420	.252	25	15	4.1	.05	6.6
20 Sec	11400	1520	.168	18	12	3.2	.05	6.7
Deep bed	17000	2450	.255	26	14	3.1	.02	6.5
Pipe	881	61	.008	4	2	2.6	.02	8.2

[a] See footnote and treatment number on Table A5. Pipe refers to pipe blanching.

[b] Inter means interference.

Table A7. INDIVIDUAL BLANCHING TRIALS FOR GREEN BEANS

Blanching[a] treatment	Treatment number	Belt loading Heat (kg/m^2)	Belt loading Hold (kg/m^2)	Effluent generation (1./case)	Product yield (%)	Solids lost as product (%)
IQB-0	1GB	6.78	86.72	1.30	90.0	--
Deep bed	2GB	7.42	--	1.10	92.8	2.09
IQB-0	3GB	4.39	55.78	.841	96.3	1.88
IQB-0	4GB	5.12	65.05	.883	95.6	.45
Deep bed	5GB	6.73	--	.618	99.4	.34
Deep bed	6GB	6.88	--	.603	99.7	.23
Averages						
IQB-0		5.42	69.20	1.01	94.0	1.16
Deep bed		7.03	--	.773	97.3	.89

[a] IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.

Table A8. CHARACTERISTICS OF EFFLUENTS GENERATED DURING GREEN BEAN BLANCHING

Treatment[a] number	BOD_5 (ppm)	COD (ppm)	Total solids (%)	Total phosphorus (ppm)	Total organic nitrogen (ppm)
1GB	5890	2910	--	53	149
2GB	9320	6530	1.26	72	235
3GB	10100	--	1.43	82	270
4GB	2230	--	.324	21	156
5GB	2560	--	.341	24	64
6GB	1790	--	.235	17	53
Averages					
IQB-0	6070	2910	.877	52	192
Deep bed	4560	6530	.612	38	117

Treatment[a] number	Volatile solids (ppm)	Suspended volatile solids (ppm)	Suspended solids (%)	Soluble phosphorus (ppm)	Nitrogen[b]			pH
					NH_3 (ppm)	NO_3 NO_2 (ppm)	NO_2 (ppm)	
1GB	--	--	--	36	11			7.9
2GB	10700	191	.026	42	5			6.5
3GB	12000	1010	.123	4	27			5.3
4GB	2700	261	.036	11	2			5.2
5GB	2850	99	.013	1	2			5.1
6GB	1980	119	.016	1	2			5.5
Averages								
IQB-0	7350	636	.080	17	14			6.1
Deep bed	5190	136	.018	15	3			5.7

[a] See footnote and treatment number on Table A7.

[b] NO_3/NO_2 and NO_2 were not determined.

Table A9. INDIVIDUAL BLANCHING TRIALS FOR POTATOES

Blanching[a] treatment	Treatment number	Belt loading Heat (kg/m^2)	Belt loading Hold (kg/m^2)	Effluent generation (l./case)	Product yield (%)	Solids lost as product (%)
IQB-6.9	1POT	3.56	17.03	.754	93.1	.43
IQB-0	2POT	5.76	18.30	1.31	93.1	.60
Deep bed	3POT	11.76	--	1.25	93.8	.78
IQB-0	4POT	5.76	18.30	1.40	92.2	.60
IQB-0	5POT	5.08	16.10	.868	95.0	.61
Averages						
IQB-6.9		3.56	17.03	.754	93.1	.43
IQB-0		5.51	17.57	1.20	93.4	.60
Deep bed		11.76	--	1.25	93.8	.78

[a] IQB-6.9 means IQB with a 6.9% weight reduction prior to blanching.
IQB-0 means IQB with no predrying.
Deep bed means deep bed steam blanching.

Table A10. CHARACTERISTICS OF EFFLUENTS GENERATED DURING POTATO BLANCHING

Treatment[a] number	BOD_5 (ppm)	COD (ppm)	Total solids (%)	Total phosphorus (ppm)	Total organic nitrogen (ppm)
1POT	5000	6340	0.930	85	302
2POT	4030	4500	0.746	66	264
3POT	3780	3640	1.01	102	397
4POT	4260	4370	0.707	65	249
5POT	4720	5790	0.856	78	329
Averages					
IQB-6.9	5000	6340	0.930	85	302
IQB-0	4340	4890	0.770	70	281
Deep bed	3780	3640	1.01	102	397

Treatment number	Volatile solids (ppm)	Suspended volatile solids (ppm)	Suspended solids (%)	Soluble phosphorus (ppm)	Nitrogen			PH
					NH_3 (ppm)	NO_3 NO_2 (ppm)	NO_2 (ppm)	
1POT	7440	775	.081	48	24	12	.29	6.9
2POT	6010	1080	.114	46	20	11	.05	7.1
3POT	8000	1490	.156	57	36	16	.09	6.9
4POT	5720	171	.020	41	23	10	.09	7.0
5POT	5550	1270	.133	52	25	13	.05	6.9
Averages								
IQB-6.9	7440	775	.081	48	24	12	.29	6.9
IQB-0	5760	842	.089	47	23	11	.06	7.0
Deep bed	8000	1490	.156	57	36	16	.09	6.9

[a] See footnote and treatment number on Table A9.

Table A11. INDIVIDUAL BLANCHING TRIALS FOR BEETS

Blanching[a] treatment	Treatment number	Belt loading		Effluent generation (l./case)	Product yield (%)	Solids lost as product (%)
		Heat (kg/m^2)	Hold (kg/m^2)			
IQB-5.6	1B	6.49	27.62	1.48	86.3	5.21
IQB-0	2B	7.66	32.55	1.84	87.8	4.01
Deep bed	3B	16.40	--	1.68	89.4	5.26
IQB-0	4B	6.88	29.28	1.61	90.0	3.76
IQB-0	5B	6.44	27.47	1.74	88.8	4.29
Averages						
IQB-5.6		6.49	27.62	1.48	86.3	5.21
IQB-0		7.00	29.77	1.73	88.9	4.02
Deep bed		16.40	--	1.68	89.4	5.26

[a] IQB-5.6 means IQB with a 5.6% weight reduction prior to blanching.
IQB-0 means IQB with no predrying.
Deep bed means deep bed steam blanching.

Table A12. CHARACTERISTICS OF EFFLUENTS GENERATED DURING BEET BLANCHING

Treatment[a] number	BOD_5 (ppm)	COD (ppm)	Total solids (%)	Total phosphorus (ppm)	Total organic nitrogen (ppm)
1B	29400	29700	3.89	145	556
2B	16700	22600	2.36	91	349
3B	21500	25700	3.34	136	492
4B	28600	19200	2.46	98	378
5B	19200	25000	2.64	95	379
Averages					
IQB-5.6	29400	29700	3.89	145	556
IQB-0	21500	22300	2.49	95	369
Deep bed	21500	25700	3.34	136	492

Treatment number	Volatile solids (ppm)	Suspended volatile solids (ppm)	Suspended solids (%)	Soluble phosphorus[b] (ppm)	Nitrogen			pH
					NH_3 (ppm)	NO_3 NO_2[b] (ppm)	NO_2[b] (ppm)	
1B	33600	378	.056		105			6.6
2B	20800	156	.017		60			6.6
3B	29000	214	.022		108			6.5
4B	21500	224	.027		61			6.7
5B	23100	170	.021		64			6.6
Averages								
IQB-5.6	33600	378	.056		105			6.6
IQB-0	21800	183	.022		62			6.6
Deep bed	29000	214	.022		108			6.5

[a] See footnote and treatment number on Table A11.

[b] Interference in tests for soluble phosphorus, NO_2-N and NO_3-N.

Table A13. INDIVIDUAL BLANCHING TRIALS FOR CARROTS

Blanching[a] treatment	Treatment number	Belt loading Heat (kg/m^2)	Belt loading Hold (kg/m^2)	Effluent generation (l./case)	Product yield (%)	Solids lost as product (%)
IQB-0	1CAR	9.86	41.82	1.30	91.6	1.54
Deep bed	2CAR	16.01	--	1.49	88.4	2.77
IQB-0	3CAR	9.86	41.82	1.27	91.9	1.86
IQB-0	4CAR	8.64	36.60	1.27	91.9	2.39
Averages						
IQB-0		9.45	40.06	1.28	91.8	1.93
Deep bed		16.01	--	1.49	88.4	2.77

[a] IQB-0 means IQB without predrying.
Deep bed means deep bed steam blanching.

Table A14. CHARACTERISTICS OF EFFLUENTS GENERATED DURING CARROT BLANCHING

Treatment[a] number	BOD_5 (ppm)	COD (ppm)	Total solids (%)	Total phosphorus (ppm)	Total organic nitrogen (ppm)
1CAR	8340	10600	1.02	66	439
2CAR	11700	12100	1.56	100	623
3CAR	10200	10700	1.25	81	512
4CAR	12500	16400	1.61	106	649
Averages					
IQB-0	10300	12600	1.29	84	533
Deep bed	11700	12100	1.56	100	623

Treatment number	Volatile solids (ppm)	Suspended volatile solids (ppm)	Suspended solids (%)	Soluble phosphorus (ppm)	Nitrogen			pH
					NH_3 (ppm)	NO_3 NO_2 (ppm)	NO_2 (ppm)	
1CAR	8520	170	.034	59	39	30	25	5.1
2CAR	12700	436	.044	100	56	44	36	5.8
3CAR	10600	283	.029	80	40	38	33	5.9
4CAR	12500	835	.097	97	48	49	29	5.5
Averages								
IQB-0	10600	429	.053	79	42	39	29	5.5
Deep bed	12700	436	.044	100	56	44	36	5.8

[a] See footnote and treatment number on Table A14.

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16. Abstract

A study on the efficacy of a new blanching system, Individual Quick Blanch (IQB), as applied to vegetables prior to canning was conducted. Peas, corn, lima beans, green beans, potatoes, carrots and beets were adequately blanched by IQB. Compared to deep bed steam blanching or pipe blanching, IQB generally resulted in a significant reduction in effluent. Slight drying of the vegetables before IQB reduced effluent even more; however, product quality was adversely affected in most cases. It was demonstrated that the IQB process can significantly reduce effluent volume and BOD generation in the blanching operation while adequately fulfilling the objectives of blanching. Recommendations for commercial development of IQB are given.

17a. Descriptors

Blanching, Individual Quick Blanching, Pollution Abatement, Water Pollution, Cannery Wastes, Vegetable Processing Wastes

17b. Identifiers

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