A SWELLING OF CANNED PEAS ACCOMPANIED BY A MALODOROUS DECOMPOSITION.

H. A. HARDING AND J. F. NICHOLSON.
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H. A. HARDING AND J. F. NICHOLSON.*

SUMMARY.

1. The value of the peas canned in the State of New York in 1900 was estimated at $1,473,912.
2. Swelling of the canned peas is the occasion of much loss to the industry.
3. This swelling is brought about by certain species of bacteria, of which the spores have survived the heating process.
4. The spores of the resistant form which was studied were destroyed on heating 2 lb. cans of peas at 240° F. (115½ ° C.) for 30 minutes.
5. When tested on a large scale at a factory this heating destroyed the germs without injury to the commercial quality of the goods.

*Resigned as Assistant Bacteriologist of this Station on June 22, 1903, to accept similar position at the Oklahoma Agricultural College and Experiment Station.
INTRODUCTION.

With the development of the country there has sprung up a number of industries which utilize the raw materials of the farm. Of these the cheese factory and creamery have long been considered as coming within the field of experiment station activity and a large amount of work is being annually directed toward the solution of their problems. At the same time the equally perplexing problems met with in condensing milk and in preserving and pickling fruit and vegetables have been very generally neglected, although in the last analysis all of these industries stand in essentially the same relation to the farmer and the consumption of his products.

FRUIT AND VEGETABLE CANNING IN NEW YORK.

The growth of this industry has been so rapid that any reliable information is out of date by the time it is available. The most accurate source of recent information is the census taken in 1900 but this can only give a general idea of present conditions.

In 1900 there were reported 511 establishments in the State of New York engaged in canning fruit and vegetables. This was a gain of 352 since 1890. These factories used in a year $5,592,463 worth of materials and turned out products valued at $8,975,321. It was estimated that 65 per ct. of the cost of materials, or $3,635,100 was for farm products. During this year these canning establishments put up 36,073,696 lbs. of peas in New York, valued at $1,473,912. In comparison with the other states New York stood first in the value of canned peas, second in the value of canned vegetables and third in the value of canned fruits.

LOSSES IN CANNING.

From the beginning of the canning industry there have been losses because a portion of the goods failed to keep. There is always a small loss due to leaky cans but there are often losses too large to be accounted for on this basis. These failures are
commonly spoken of by the canners as "swells" and "sours."

Cans are said to be "swelled" or fermented when the normally depressed ends bulge outward. When such cans explode or are opened the material contained is usually decomposed, vile smelling and worthless as food. There are at least two classes of exceptions to this description of the contents: Certain fruits often bulge slightly when held over winter in storage, but on opening they are found unchanged and fit for food; and cans which have undergone souring will often swell if kept for a time in a warm place.

Since it could not be overlooked, swelling has been known as long as canning has been practiced and losses of this kind have been strong incentives for improving methods. "Soured" cans give no external evidence of being abnormal; but when opened the contents emit a sour smell and have an acid flavor. With peas, the odor is not disagreeable, the liquor is milky and the flavor ranges from faint to decidedly acid. Where the acid is formed after the cans are heated, especially if the goods are held some time at 70° F. or above, enough gas is formed to cause the ends to bulge slightly. In such cases the cans are commonly classed as "swells." However, in case the acid is produced before the cans are heated or where the cans have been held at low temperature no change is apparent until the cans are opened by the consumer. As long as the public was not educated to expect fine quality, a considerable amount of sour goods was undoubtedly consumed without question. Now the consumers have become more discriminating and the increased protest against sour goods is one of the results.

CAUSE OF THESE LOSSES.

The fact that fermentations in general are so commonly caused by the lower forms of plant life leads to the widespread belief that all the difficulty in keeping canned goods can be attributed to the same cause. While it is probably true that a large proportion of the swelling and souring is due to the growth of bacteria within the cans undoubtedly exceptions will be found. It is also true that there are a number of different species of bacteria which produce swelling or souring of the same vegetables in different factories.
FACTORS WHICH ASSIST IN KEEPING CANNED GOODS.

There are several factors which combine to make commercial canning possible. Fresh and clean fruits and vegetables are desirable because they carry smaller numbers of the germs which it will be necessary to destroy. This means cleanliness in the utensils and persons with which the materials come in contact before entering the cans. Pure air is desirable, especially for the workmen, but its effect on the product has often been over-estimated.

Where large quantities of sugar are used with fruits the sugar tends to restrain the growth of germs which may be present. This is the basis of the keeping quality of household preserves. Maple syrup which weighs 11 lbs. to the gallon contains about the minimum amount of sugar which will prevent fermentation under favorable conditions. Even maple syrup kept warm commonly ferments. In the quantities used with vegetables the sugar increases, rather than retards, fermentation.

In their zeal to sell saccharin the agents often claim high germicidal properties for this substance. As used in peas, the germicidal property of saccharin, if present, is too slight to be of practical use. Stress is also laid upon the point that saccharin does not break up into gas under the influence of bacteria. As the sugar in the peas themselves will furnish sufficient gas to explode the cans this item is of little value.

The acid in fruits and certain vegetables increases the effectiveness of the heating in a marked degree. In practice, pieplant keeps with far less heating than is required by asparagus. Peas which had soured after processing for 30 minutes at 236° F. were heated for a few minutes at 212° F. It was found that in many cases in the presence of the acid, this slight heating had killed all the germs.

Antiseptics have held, in the past, a considerable place in the fight which canners have made against fermentation. They are still used to a sufficient extent to induce liberal advertising by the manufacturers of certain proprietary compounds. An analysis of some of the leading compounds of this class has shown that they are combinations of a few well known chemicals of which formalin, boracic acid and salicylic acid are the most common
examples. If canners will use these chemicals they would display business foresight in buying them in pure rather than in proprietary form since they can be obtained pure for much less money.

The objection to the use of these substances because of their effect upon digestion is well known and there is a growing tendency to legislate against their use. It has been maintained that the use of antiseptics is unavoidable in certain departments of canning; but the list of substances which have not been successfully canned without the use of antiseptics is small. The use of such material in many cases is an admission either of carelessness or ignorance on the part of the canner.

It is a matter of common observation that the absence of a vacuum means trouble. From this has grown the idea that the vacuum itself prevents decomposition. Nothing could be farther from the facts. The souring of peas often progresses to a point where the peas are worthless before the vacuum is destroyed. Moreover, cans of peas will keep satisfactorily in free contact with the air if, before processing, the opening is provided with a cotton plug so as to prevent germs from entering.

The vacuum is useful in decreasing the tension in the can in connection with the heating and its absence indicates a leak which will allow germs to enter.

Commercial canning depends very largely upon heat as a means of preventing undesirable changes; and the progress of the business has been marked by improvements in the means of heating and in the knowledge of the effects of various degrees of heat. Beginning with open tanks of water which were limited to 212° F., there has been developed the closed kettle where all temperatures up to 250° F. are in use. Prescott and Underwood stated that when working at 236° F. that temperature was found at the center of a 2 lb. can of standard packed peas in 10 minutes while it took 40 minutes heating at 250° F. to raise the center of a like can of corn to 236° F.

2 Paper before Rochester meeting of Canners' Association. Trade, 23: No. 29, Feb. 22, 1901; also Canner and Dried Fruit Packer of same date.
BACTERIA AND THEIR ACTION.

For convenience members of the plant world are often referred to by groups. The members of one of these groups, characterized by their small size and simple form are referred to as bacteria. Like mould spores and yeast cells the individual bacterium (plural bacteria) is too small to be seen by the unaided eye but like both mould and yeast it often grows into a mass which can be readily seen.

Food can be used by plants only when it is in solution, so that the germs live, not on the vegetables directly, but upon the soluble material in the cans. By means of enzymes which they secrete they are able to soften the solid vegetables. They all require oxygen in some form and give off carbon dioxide, which is partly responsible for the bulging of the cans. Sugar in moderate quantities is especially useful to those growing in canned goods since it furnishes them with oxygen.

The character of the decomposition depends partly upon the nature of the original compounds and partly upon the form into which the particular germ breaks them in extracting the portion desired as food. The germs causing the swelling of peas break up the sugar in such a way as to produce a large amount of gas and a small amount of acid. The ones producing souring in peas break up the sugar so as to leave a large amount of acid and little or no gas.

BACTERIA ARE OF DIFFERENT KINDS.

In objects which are only about $\frac{1}{3000}$ of an inch wide and a few times longer than broad there is but a limited amount of information to be derived with a microscope. However some forms are round like miniature peas while other are rod-like. The latter differ slightly in plumpness and in the position and appearance of their spores. The spores are very resistant bodies formed within the cells and capable of starting growth anew at some later time. The growing cells are killed by any ordinary amount of cooking but the spores often survive and cause trouble.

The bacteria which are capable of destroying canned goods are not only of different species but, what is of more importance to
the canners, the spores of different species are capable of withstanding different amounts of heating. As a result of this, canners who have been processing successfully at a low temperature for a number of seasons suddenly find themselves in trouble when a more resistant species gets into the cans.

Until outbreaks of swelling and souring of a given vegetable have been studied in a number of factories we will not be able to draw safe general conclusions as to what temperature can be absolutely relied upon to keep the given vegetable under all conditions. While these facts are being ascertained the safest practical plan will be to give the cans the amount of heating required to kill the most resistant species known to trouble the particular vegetable and as much more as the vegetable will stand without injury to its commercial quality.

SWELLING OF CANNED PEAS.

CAUSE DETERMINED.

INTRODUCTORY NOTES.

In peas, acid is lacking, the amount of sugar and nitrogen is such as to favor fermentation, and heat alone must be relied upon to prevent decomposition. Add to this the fact that heat penetrates the cans rather slowly and it is seen why peas are among the most difficult vegetables to can satisfactorily.

In 1902 our attention was called to a serious outbreak in swelling in the product of a large factory. In connection with this work we attempted to determine three points: (1) The cause of the trouble, (2) the amount of heating necessary to obviate the trouble, (3) the limit of heating which was practical without injury to the commercial quality of the peas.

In order to test these results under commercial conditions and in order to determine the limit of heating which peas would stand without injury it was necessary to work with fresh peas at a factory. The Geneva Preserving Co. very kindly gave us every facility for carrying out this work at their plant and in this connection we canned a ton of peas, including early and late varieties, under actual factory conditions.

The lively and helpful interest which all members of the force took in the work was one of its most pleasant features and to them
we return our sincere thanks. We are especially indebted to Manager Thorne, upon whose experience we have drawn largely throughout the progress of the work. We are also indebted to the canners of the State who by furnishing information on various points have enabled us to give an additional test to the practicability of our conclusions.

PREVIOUS STUDY OF THIS PROBLEM.

The swelling of canned peas was, so far as we have been able to learn, the first trouble of this nature to be successfully attacked by modern science. In 1895 Russell\(^3\) studied an outbreak in a Wisconsin factory. He found that the swelling was the result of the action of germs which had survived the heating process and that the trouble could be prevented by increasing the temperature of processing.

While he gave but a hint as to the characteristics of the causal organism it would seem to be slightly different from the one with which we had to deal in the present outbreak.

THE OUTBREAK AT THE FACTORY.

The New York factory where the outbreak occurred had been processing peas in 2 lb. cans at 230° F. (110° C.) for 30 minutes for a number of seasons with good results. In 1902 they began on Alaska peas on June 20; and on July 10 swelling was evident in the stock room.

At this date a portion of the peas had already been shipped but those remaining in stock and not swelled were reheated at 238° F. (114½° C.) for 35 minutes. After this heating, all cans where the fermentation had started remained bulged on cooling. Those where it had not yet started were rendered sterile. The loss was practically total on all goods which had been shipped and in those reheated graded down to almost nothing on the pack of the preceding day. An examination of the reheated goods showed that they were in good condition except for a slight cooked taste due to the double heating. During the remainder of the season the peas were processed at 238° F. (114½° C.) for 35 minutes with very little loss.

THE SWELLED CANS.

Externally the cans presented the usual bulged appearance, the bulge showing more quickly at blood heat and increasing with lapse of time. In some cases the side seams gave way, in others the tops were blown off, widely scattering the contents. The peas emitted a disagreeable stench tinged with the odor of hydrogen sulphide. The bodies of the peas were mushy and the skins inflated with gas, like miniature balloons. The liquor was darkened and of a greenish tinge due to the small particles of the ruptured peas.

Occasionally cans were found which did not agree with this description. These were usually but slightly swelled and the odor of the contents was acid but not especially disagreeable. The peas appeared about normal but the liquid was distinctly milky and had a sharp, acid taste. A very few cans gave evidence of a mingling of these two forms of decomposition.

BACTERIA IN THE SWELLED CANS.

A microscopical examination of the juice from a swelled can showed that there were large numbers of bacteria present, while a like examination of a good can failed to show any bacteria.

Some of the sour cans contained a round or coccus form while other sour cans contained rod form. The coccus form was studied sufficiently to show that it would not only sour cans of peas when artificially introduced but that when kept at blood heat these cans would commonly bulge.

The vile-smelling cans which made up more than 99 per ct. of the trouble all contained a rod form. This was plumper than those observed in the sour cans and in many cases was distinguished by a swelling at one end giving it the appearance of a drum stick.

BACTERIA CAUSE THE SWELLING.

The plump rod form having swollen ends was in many cases the only form to be found in the swelled cans. From such cans cultures were prepared at the laboratory and this germ separated from all other forms. A considerable number of cans of sterile peas were vented and a part of them received a culture of this germ. All were now resoldered and kept at blood heat. All of
the inoculated cans swelled within 24 hours. In many cases the tension became sufficient to burst the cans. The cans which had been vented and resoldered without inoculation did not swell. An examination of the inoculated, swelled cans showed only the single form present.

These facts, then, identify the causal organism: (1) The finding of large numbers of a certain species of bacteria in spoiled canned goods while satisfactory goods are sterile; (2) the isolation and study of this germ in pure culture; (3) the inoculation of sound goods with these cultures and the production of the original trouble; (4) the reisolation of the germ from these goods and (5) the determination that it is the original species. These points complete the cycle of proof required to establish the fact that the original trouble was due to the activity of this germ.

In this case, we can apply the additional test that when inoculated into sound cans the suspected germ should be able to withstand the amount of heating to which the spoiled cans were originally subjected. Accordingly sterile cans were carefully opened, inoculated with pure cultures of the rod form from the spoiled cans and resoldered. The cans were then processed at 230° F. for different lengths of time.

**Two Pound Cans of Peas Heated to 230° F. (110° C.) at Laboratory.**

<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. cans heated</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>No. cans swelled</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Percentage swelled</td>
<td>83</td>
<td>100</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

These cans were not kept under observation after about 10 days since at that time it was evident that this germ was capable of surviving a processing at 230° F. (110° C.) for 30 minutes. Had they been observed longer probably other cans would have swelled, since in later work we found that a considerable number of experimental cans swelled even after being kept at 80° F. (26° C.) for two months.

From all this it would seem fair to conclude that the rod-like spore-bearing form found in the cans which had swelled at the factory was the cause of the swelling.
DESCRIPTION OF THE CAUSAL ORGANISM.

Form.—The rods are 4–6μ long by 1.5–1.8μ wide and usually occur singly.

Stain.—Rods readily take the ordinary stains but do not take the Gram stain.

Spores.—The oval spores, one in a cell, are usually near the end of the rod. The rod swells at the point where the spore is to appear before the latter is visible. The ripened spore has a greater diameter than the original rod. Spores are formed so freely that a culture is rarely free from them, new ones being formed before all of the old ones have sprouted. They often make up more than 50 per ct. of old cultures.

Motility.—Young cultures are actively motile and even the swollen rods in which the spores are forming sometimes swim about. Each rod is provided with several peritrichic flagella.

Culture characteristics.—So far as tested this germ failed to grow in contact with the air. Even where oxygen was excluded it grew poorly or not at all on the ordinary peptone culture media. The addition of sugar stimulated the growth. Cane sugar dextrose and lactose are broken up with the formation of gas and acid. Growth on lactose agar is scanty, white and often in discrete colonies. On lactose gelatin, stab growth is not visible but after a considerable interval circular liquified areas appear within the body of the gelatin.

Temperature exerts a marked influence upon the rate of growth. At 22°C. (71.6°F.) growth on lactose agar slopes appears only after two to three weeks while at 37°C. (98.6°F.) it is equally abundant in 2–5 days.

The vigor of growth is closely connected with the nitrogenous part of the media. The juice from canued peas or broth made by cooking ordinary white beans gave more vigorous growth than ordinary lactose bouillon. The fluid became turbid in 2–3 days at 37°C. (98.6°F.) with later formation of a pale sediment. There is a rapid and fairly abundant growth at this temperature of mass cultures upon media made by the addition of agar and salt to either the pea or the bean juice.
REMEDY APPLIED.

AT WHAT TEMPERATURE SHOULD PEAS BE PROCESSED.

The true cause of this outbreak having been established the next step was to determine the amount of heating necessary to destroy this organism when present in the cans. The use of 230° F. (110° C.) or any higher temperature would undoubtedly accomplish this provided the heating was continued a sufficient length of time.

The function of processing peas is twofold. First it must insure the preservation of the goods; second it should cook them just short of the amount required before consumption. Provided it does not injure the quality of the peas a high temperature is preferable since it shortens the time required for processing and thereby relieves the most congested part of the factory.

FACTORY PRACTICE.

In selecting a desirable temperature no more satisfactory guide could be expected than a summary of the practice of the canners of the State, since in many cases this represents the results of 20 years' practical experience. Accordingly blanks were sent to all the canners of the State known to be packing peas. Canners have been so frequently charged with keeping their methods secret so that the promptness of the replies came as an agreeable surprise. With one or two exceptions the desired information was furnished by every canner and often accompanied by an expression of interest and an offer of coöperation.

DETAILS OF PROCESSING PEAS, FROM REPORTS OF NEW YORK PEA CANNERS, 1902.

<table>
<thead>
<tr>
<th>Temperature Deg. F.</th>
<th>Number of Factories</th>
<th>Time processed in minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>230</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>235</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>236</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>238</td>
<td>2</td>
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</tr>
<tr>
<td>240</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>244</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>246</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
This table is based upon the replies for 1902 and shows the situation at a glance. It includes the returns from 39 factories but really represents a much larger number since the large companies commonly filled out a single sheet to cover their numerous branches. The common practice is to use a single temperature and vary the length of exposure according to the condition of the peas. Since 240° F. (115\(\frac{6}{9}\)° C.) was so commonly used it was taken as the most desirable temperature for further work.

**The Effect of 240° F. (115\(\frac{6}{9}\)° C.) on the Germs.**

In order to test this matter under satisfactory conditions the work was carried on at the factory. Each can was inoculated with a large number of spores of the gas forming germ.

The inoculations were made as the cans came from the filler and they were treated in the usual manner in other particulars. They passed to the processing room within an hour and there their method of treatment differed from the normal only in that they were heated for special lengths of time. After heating they were dropped at once into a stream of cold running water and thoroughly cooled.

The largest size and smallest size of Alaska peas were used and the medium size of Advancers. They were run in batches of 50 cans of each size at each temperature. The Alaska peas were run on July 8 and the Advancers July 13. The cans were removed to the laboratory where they were kept under observation for 8 months. The temperature of the store room was kept between 80° F. (26\(\frac{6}{9}\)° C.) and 90° F. (32\(\frac{8}{9}\)° C.) for a number of months.

**Two Pound Cans of Peas Heated at 240° F. (115\(\frac{6}{9}\)° C.) at Factory.**

<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. cans heated</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>No. cans swelled</td>
<td>150</td>
<td>99</td>
<td>73</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Percentage swelled</td>
<td>100</td>
<td>66</td>
<td>49</td>
<td>4</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The above table shows that when this particular organism or one equally resistant is present it will be unprofitable to process at 240° F. (115\(\frac{6}{9}\)° C.) for a shorter time than 30 minutes.
These cans differed from the normal only in two particulars. We made sure that they contained spores of the germ we desired to test and after the test we held them at a temperature which would encourage the growth of any germs which might be alive in the cans.

On examining the spoiled cans it was noted that those heated but 10 minutes contained a mixture of different forms while those heated for a longer period were quite uniformly free of all but this one kind. In view of these results it is hard to understand how factories can sterilize cans under any circumstances when processing but 10 minutes at 240° F.

The factory where the outbreak occurred has used 240° F. for 30 minutes through a large part of the season with no loss from swelling aside from occasional leaks.

LIMITATION OF THESE RESULTS.

It should not be forgotten that while these results and recommendations are believed to be generally applicable to what may be expected in practice they are strictly reliable only when combating this or a less resistant species. While this germ has proven to be unusually resistant to heat it is quite possible that some factory may have trouble with another germ which is even more resistant. For this reason it was thought best to study this germ and describe it in such a way that in future outbreaks we can determine whether we have to do with the same or a different germ.

EFFECT OF 240° F. (115° C.) ON COMMERCIAL QUALITY.

Some difference of opinion exists regarding the effect of 240° F. upon the texture of the pea and the clearness of the liquid.

This was brought out in the replies from the canners. Twenty-nine canners report their experiences with this temperature. Eighteen have never observed bad effects, while eleven point out dangers, in different directions. One notes a tendency to scorched flavor in the smaller sizes and two speak of the bursting of the tender peas. Seven note that in the mature peas there is trouble with the liquor becoming muddy if the heating is too long continued.

The cans which had been heated at the factory to determine
the death point of the gas-forming germs gave us an excellent opportunity to judge of the effect of heating for various intervals upon the quality of the product.

The Alaska peas were examined by three competent judges immediately after cooling with the following results:

(1) The liquor was good and clear but seemed slightly brown in all cases except those heated but ten minutes. The others seemed all of the same shade.

(2) The peas were darkened in all cases where heated more than ten minutes. This darkening increased in all with the length of exposure but was much more marked in the larger size (No. 4).

(3) There was a scorched taste in those heated thirty-five, forty and forty-five minutes which in the two longer intervals was sufficiently marked as to be objectionable in the market. No scorched taste was distinguishable in those heated thirty minutes or less.

(4) There was a slightly scorched smell in cans heated thirty-five minutes or longer but not enough to be objectionable.

At the end of eight months the cans heated but ten minutes had spoiled but samples of those remaining were submitted separately to eight men familiar with pea canning, three of whom were well posted as to the demands of the market. Their opinions varied but little, the better posted men being slightly more critical; and may be summed up as follows:

Alaska No. 1.—All pass without question. Color fine, liquor slightly darker in those heated thirty-five minutes and longer. Liquid not muddy in any. No scorched taste except faint trace in those heated forty and forty-five minutes.

Alaska No. 4.—Color dark in all but not muddy. Possibly due to short blanch. Those heated thirty minutes or more would be liable to complaint on color. No scorched taste.

Advancers No. 3.—All pass without question. Color good and liquor not muddy. Very faint scorched taste in those heated forty minutes.

There was a noticeable decrease in all objectionable results of the high heating during the interval between the two examinations except in the case of the color. When first examined the
liquid was but slightly colored while the peas were noticeably
darkened. On standing this discoloration passed from the peas
out into the liquor. It is thought that by lengthening the
blanching process this trouble could be largely overcome.

The decrease in the scorched flavor was especially marked.
Immediately after cooking it was very noticeable in certain cases
while at the later examination it was not detected at all by a
number of the judges.

CONCLUSION.

Swelling of canned peas is caused by bacteria which form
such resistant spores as to survive ordinary processing.

In the outbreak studied, 240° F. (115½° C.) for 30 minutes was
found to be sufficient to destroy this germ when present in the
cans in large numbers. This temperature has since been used
by the factory with complete success.

Except under unusual conditions this amount of heating does
not injure the commercial value of the peas.

The aim of this investigation has been to determine a safe
minimum amount of heating. The amount additional, if any,
which should be used in any case to produce the desired cook is
a matter for the judgment of the processor and one in which he
will display his mastery of his art.