A study of the quality and bacterial content of home canned peas as affected by varied methods and periods of precessing
by Mary Esther Evans

A THESIS Submitted to the Graduate Committee in partial fulfillment of the requirements for the degree of Master of Sciene in Home Economies at Montana State College
Montana State University

Abstract:
1.In this study of home canning, peas of the Laxtonian and Perfection varieties were used. The Laxtonian peas were shelled by hand in the laboratory, while the Perfections were shelled by machine in the field.

2? The peas were processed by three different methods and for varied periods, as follows:- Oven method - 90, 120,. 150, 180 and 210 minutes* Water bath method - 180, 216, 252, 288 and 324 minutes. Pressure cooker method - 30, 40, 45 and 50 minutes.

3». The tests that furnished the data for this study were carried out at an altitude of about 5000 feet above sea level, where the temperature of boiling water varies from 202° to 204° P.

4» The percentages of spoilage occurring in the peas canned by the various methods and periods were as follows Oven - Laxtonian - 90 minutes - 72.7% " 120 " 90.9 " 150 " 16.7 " 180 " 40.0 Perfection 210 " 51.4 Water Bath -¦ Laxtonian - 180 minutes - 36.4% ir n • " 216 " 8.3 Perfection 216 " 70.8 Laxtonian 252 " 8.3 Perfection 252 " 46.2 Lstxtonian 288 " 0.0 Perfection 288 " 9.6 Laactonian 324 " 8.8 perfection 324 " 4.2 Pressure Cocker — No spoilage So All of the jars of peas were examined' for "bacterial content-. The organisms isolated from the spoiled peas were mainly spore-forming facultative aerobes, often found in soil.

The higher rate of spiiage noted in the Perfection peas that were shelled in the field confirms other experimental work which has shown the relation between spoilage in peas and soil contamination.

¦7. When the unspoiled peas were Judged for palatability, those processed for the higher water bath periods, 283 and 324 ¦ minutes, and some of the peas processed in the pressure cooker for 50 minutes were scored higher than the others.

8-. Many peculiar flavors were noted by the judges. It is suggested that one of these,, a "beefy" taste, may be associated with a glutamate having a meat-like flavor.

.9., The penometer tests showed that the majority of the peas-, processed by all the periods and methods., tended to be too soft rather than too hard.

10. The color of the canned peas, as determined by comparison with standard color disks, was found to undergo a decided change during six months'* storage in the dark*' This color change was attributed to the destruction of chlorophylls 11,. in the oven-canned peas processed for periods ranging from 90 minutes•to 210 minutes, spoilage occurred to such an extent that this method with the periods 'used cannot be recommended. The quality of the peas did not prove desir- able, and the probability of success from lengthening the periods of processing by this method is not indicated.

12. The amount of spoilage among the jars of peas processed by the water bath method for periods of 180, 216, and 252 minutes was too great to permit the recommendation of these periods of processing by the water bath method at an altitude of about 5000 feet, The quality of the unspoiled peas seemed to indicate that further extension of the processing period would produce satisfactory results.

15. The loss from spoilage of -the peas, processed by the water bath method for the two longer periods, 288 and 524 minutes, was no greater than the amount which might be expected to occur because of slight imperfections in the equipment for home canning. The quality of these peas was judged to be good, in regard to palatability, texture, and appearance.

14. There was no spoilage among the pressure cooked peas for any of the processing periods. However, the 50 minute period peas were more pleasing in flavor than those processed for shorter periods, and were comparable to peas processed by the water bath method for 288 and 524 minutes.

A STUDY OF THE QUALITY AND BACTERIAL CONTENT OF HOME CANNED PEAS AS AFFECTED BY VARIED METHODS AND PERIODS OF PROCESSING

by

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A THESIS

Submitted to the Graduate Committee in partial
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INTRODUCTION

Among the most popular products of the home garden are green peas which have for a long time been considered a choice vegetable. Unfortunately the season during which fresh peas may be enjoyed is comparatively short. It is therefore desirable to preserve them in such a way that they will retain their original palatability to the greatest possible degree.

Homemakers have long been aware of the existing problems connected with canning peas, for frequent spoilage has proved their present methods unsatisfactory. Whether this spoilage is due to canning conditions, to the kinds of bacteria present, or to the nature of the vegetable itself is a question which has not as yet been satisfactorily answered. That the nature of the vegetable complicates the problem is quite possible, since peas with their highly concentrated protein and carbohydrate content, and their necessary exposure to contamination through the shelling process are quite different from other vegetables which are ordinarily preserved.

In the study of home canning there has apparently been little effort made to determine by experimental procedure wherein one method or period of processing is superior to an-

other, either in prevention of spoilage or in preservation of desirable quality. It is evident therefore that a comparison of the results of canning peas by varied methods and periods of processing is necessary in order to solve many of the home problems which are connected with the successful preservation of this vegetable.

HISTORY

The early studies of canned foods were concerned with spoilage. There was little difficulty in detecting spoilage, for it was made evident by the undesirable changes which had occurred in the canned food. An excessively soft or discolored product, having a disagreeable odor, and often containing gas bubbles, has always been treated with suspicion by (any) homemaker.

According to Sunderlin, Levine, and Nelson (27) who made a study of indices of spoilage, physical evidence is still the most reliable criterion for spoilage determination. In their laboratory, physical tests consisted of observations of odor and records of suction. Despite the apparent accuracy of physical tests, however, it was concluded that it would be necessary to use both chemical and bacteriological methods to detect all kinds of spoilage.

Chemical methods for spoilage determination as used by

these workers included tests for total acidity, measurement of hydrogen ion concentration and formol titration. Though the results of these tests were not in themselves conclusive they were considered valuable supplements to the other methods.

Bacteriological tests depend on examination of stained smears made directly from the canned food, and the culture of a sufficient quantity of the suspected material. Such studies are more valuable in determining the cause of spoilage than in proving its existence. In 1921 Lang (18) pointed out that home canned products in first class condition were not necessarily sterile, but frequently contained spores which did not cause spoilage, provided the can had a good vacuum and a tight seal. This being accepted, the mere presence of bacteria cannot be absolute proof of spoilage.

For the most part, commercially canned foods have been the subject of these spoilage studies under the leadership of the National Canners' Association. However, some studies have been made on home canned vegetables of the non-acid group, to which peas belong. Sunderlin (27), Lang (18), and Normington (22) have described specific bacteria isolated from canned peas or vegetables of comparable acidity. The organisms most frequently found were aerobic bacteria, which group includes Bacillus subtilis, B. megatherium, B. mesentericus, B. vulgatus, B. cereus, B. mycoides, and others. Anaerobes and thermophiles of many sorts have also been described as causative organisms

in spoilage of canned vegetables.

Identification of the organisms isolated from canned foods helps to ascertain the source of contamination. Normington (22) on finding chiefly soil organisms of the Bacillaceae family assumed that most spoilage bacteria in canning came from the soil. She therefore suggested that the organisms gained entrance to the products through soil or dust on pods transferred to the peas in shelling, dirt from the hands of the shellers, peas dropped on the floor and picked up, or dust settling on the peas during storage before canning.

One of the factors affecting the number of organisms present during the canning process is the condition of the material to be canned. All workers emphasize the maintenance of cleanly conditions during the preparation of the products for canning. Normington (22) cites lack of careful handling and the resultant soil contamination as conditions largely responsible for high bacterial content.

Nearly all bulletins, containing general canning instructions, carry the injunction to can fresh material. If the raw food is kept for some time before canning, the opportunity for multiplication of the bacteria present is great, particularly where there is warmth, moisture, and darkness, so that a delay of even a few hours markedly complicates the problem of successfully processing the product.

Certain unknown quantities increase the difficulty of

applying bacteriology to the solution of canning problems. Most important of these is the initial concentration of spoilage bacteria. Wide variations in this concentration prevent recommended processing methods from being altogether exact and constant (15). This effect of numbers has been consistently demonstrated in heat-resistance studies in the Research Laboratories of the National Canners' Association (4).

Methods of processing canned foods have an important bearing on spoilage percentages, since the destruction of spoilage bacteria is dependent on the effectiveness of the processing method. Processing designates the heat treatment which the product undergoes after the material is placed in the covered can. Very little experimental work has been done to show the relative merits of the different home methods which are in common use,- open kettle, water bath, pressure cooker, and oven processing.

When the open kettle process is used the canning material is thoroughly cooked in an open kettle and while hot is packed into jars which have been thoroughly scalded. The jars are at once completely sealed. Both the adequate cleansing of the jars by scalding and the high temperature of the canning material at the time when the jars are filled, are factors in the success of the open kettle process. Most important, however, is the acidity factor. By general experience the conclusion has been reached that only those foods, such as fruit, which

have a relatively high acid content, can be safely processed by the open kettle method.

The water bath method of processing is also carried out at the temperature of boiling water. The food may or may not be precooked, that is, given a short heat treatment before being placed in jars. After being filled and sealed, the jars are immersed in a boiling water bath, and are allowed to remain for the length of time recommended for the particular food which is being canned.

The pressure cooker method also requires that the food be packed in the jars, with or without precooking, before being placed in the pressure cooker. The food is then subjected to a relatively short period of heating by means of steam under pressure. The temperature maintained in the pressure cooker is considerably above the boiling point of water, the recommended temperature for peas being 240° F. The higher temperatures obtainable in the pressure cooker have made this method appear essential for processing those foods which are admittedly difficult to can successfully. Since the initial cost of the pressure cooker practically prohibits the ownership of this piece of equipment in many cases, it seems desirable to make a careful comparison of this method with the less expensive methods of processing.

Oven canning is the most recent processing method. The jars are filled with food which has been precooked, and are

sealed before being placed in the oven. Although the oven temperature is kept at about 250° F. there have been no data reported in the literature concerning the internal temperature reached.

Experimental data to show the relative effectiveness of these methods of processing are not extensive. Normington (22) has carried out some experiments in canning vegetables by the water bath and pressure cooker methods. Her results indicate that there is very little difference in amount of spoilage in the pressure cooked vegetables and those processed by the water bath method.

An important condition affecting the occurrence of spoilage in canned foods is acidity, mentioned above in connection with open kettle processing. Peas, as typical non-acid vegetables, are never canned by the open kettle method, and it is the recommendation of the United States Bureau of Home Economics (26) that peas be processed solely by the pressure cooker method. Some workers, however, have proposed the addition of acid to non-acid foods in order that such foods may be processed at a temperature of 212° F. Cruess (9), after demonstrating by experimental work that lowering the pH decreased the amount of sodium benzoate required to prevent the growth of certain organisms, concluded that the preservation of non-acid foods might be greatly facilitated by the addition of acid. Skinner and Glasgow (24) have made practical application of

Cruess' suggestion in the home canning of asparagus. By the use of vinegar the processing time at 212° F. was reduced from three hours to one and one-half to two hours, with an accompanying decrease in the percentage of spoilage over that occurring when no acid was used. By bacteriological examination it was found that those jars treated with acid showed the presence of organisms less frequently than did those not treated. Whether or not the amount of acid added detracts from the normal flavor of the product is still in question.

Conditions of altitude are also known to affect the success of canning processes, particularly those in which steam pressure is not used. In the case of water bath processing, provision has been made for canning at higher altitudes by a general theory based on physical laws. This rule, as given by the United States Bureau of Home Economics (26), is "for all altitudes above 1000 feet the time should be increased 20 per cent for each additional 1000 feet." For oven canning a time increase of 50 per cent is recommended. Unfortunately there are no data to show the comparative effectiveness of pressure processing, oven, or water bath processing for prolonged periods.

The effect of storage on spoilage of canned goods has been merely mentioned by most writers reporting spoilage studies. Some experimental work on this subject was done by Biester, Weigley and Knapp (2) at the University of Minnesota in 1920. Several different kinds of vegetables, both acid and

non-acid, were processed by the water bath method. Some jars were stored in an ordinary root cellar for four months, some were stored in a bacteriological incubator for ten days, while others were stored in the root cellar for ten days. The keeping quality of the canned products was judged according to taste by the members of the Home Economics instructional staff. Results showed that the greatest percentage of spoilage took place in the jars stored for 10 days in the incubator. One of the conclusions was that storage conditions may markedly affect the percentage of spoilage. The desirability of storage immediately after canning was also indicated.

By far the greater number of the studies which have been made on canned foods have been related to spoilage and its causes. Only recently has the quality of unspoiled canned foods been investigated. However, before studies of quality can be made some standards of quality must be adopted. These have been supplied for use in judging many of the common fruits and vegetables by the Food and Drug Administration of the United States Department of Agriculture (11). The standard of quality and condition for canned peas is given as follows:- "Standard canned peas are the normally flavored and normally colored canned food consisting of the tender, immature, unbroken seed of the common or garden pea (Pisum sativum), with or without seasoning (sugar, salt), and with or without added potable water. The product is practically free from foreign material

and, in the case of products containing added liquid, the liquor present is reasonably clear."

The varieties of peas for canning should be chosen to conform to these requirements inasmuch as the quality may be affected by the variety. The Association of New York State Canners, Inc. has stated that the varieties of peas preferred for canning consist of an early variety having a smooth skin, and later varieties, sugar peas or sweet peas, having a wrinkled skin and sweet flavor (20). In regard to variety of seed, studies have also been made to determine the relative percentages of hard shell in peas and bean varieties (12). Hard shell, or the presence of impermeable seeds, was recognized by permeability tests in which there was evidence of great variation in the resistance of seed coats to the entrance of water. No correlation between color and hard shell was observed and there appeared to be no marked difference between the smooth and wrinkled varieties in percentage of hard shell. The least percentage of hard shell indicates the greatest tenderness of seed coats.

The quality of the peas is probably more dependent upon prompt harvesting than on variety, since low sugar and high starch content are typical of peas of low quality, whether as a result of delayed harvesting or as a varietal characteristic. Boswell (7) has shown through biophysical and biochemical studies of the stages of ripening of peas that prompt harvesting upon the attainment of marketable size is imperative to avoid

the decrease in sugar content and increase in starch content which occurs as the peas mature. From the standpoint of quality, late planting is to be avoided, since higher temperatures make a timely harvest increasingly difficult.

Even though the peas are harvested at the stage when they are of highest quality, a generally recognized deterioration occurs on standing. The chemical changes which take place at this time are in all probability, according to Kertesz, (17) due to the action of enzymes. He has observed that changes in freshly picked peas kept at a temperature as low as -20° C. for twenty-four hours are marked. This observation, however, is qualified by the author's comment that enzymatic action may have had sufficient opportunity to bring about these changes during the short period before the peas reached the low temperature. He states also that deterioration during storage in pods is probably not so rapid or extensive as that occurring in shelled peas. Gowen's work showing that calcium begins to migrate to the skin and causes an appreciable toughness within a few hours is cited by Sayre, Willaman and Kertesz (23). These workers have studied the correlation of a higher percentage of lime in the skin with its greater toughness, regardless of thickness of the skin. In addition to the changes in chemical composition which Boswell listed in studies of maturing peas, Sayre, Willaman and Kertesz have noted an increase in calcium.

The toughening effect of calcium on peas is again mentioned in connection with canning procedures. Water containing an excessive amount of calcium should not be used because of its detrimental effect on the tenderness of peas (3). For the same reason commercial salt high in calcium is to be avoided. However, Greenleaf has found that most commercial salts are usable since the amount of calcium in grader brine is not absorbed unless it exceeds 1% (13).

The best quality of canned peas has a fairly clear liquor. A cloudy appearance is thought by Loudon and Spencer (19) to be caused by rough handling in blanching, or by the inclusion of split or broken peas in the jars. Peas which are too mature or are overcooked in the blanching process often burst and allow the starch to escape into the liquid. Other writers have explained that some of the starch in the peas is dissolved during sterilization and this slowly coagulates to form a milky suspension of white particles. Several weeks may be necessary to complete the precipitation but eventually all of the starch originally dissolved is coagulated (25).

Very little has been written concerning the effect of storage on the quality of home canned foods. In connection with the storage problem, Biester, Weigley and Knapp (2) attempted to compare the resulting palatability of the products. From that standpoint, the quality of canned vegetables stored in the root cellar was judged to be superior to that of the canned vegetables

stored at incubator temperature.

The standard of quality and condition for canned peas as given under the McNary-Mapes amendment to the federal food and drug act has been quoted (11). To help the commercial canners meet the requirements of this amendment, devices for standardization have been suggested. Foremost of these is an apparatus for determining the tenderness of certain canned fruits and vegetables (6). This device has been successfully used to measure the tenderness of canned peas, serving as an accurate and impersonal judge of this factor of their quality (6).

The McNary-Mapes amendment also requires that canned peas be "normally colored". This term excludes distinctly off-colored peas, brown, brownspotted, white or yellowish white. For experimental purposes and comparative work, however, an accurate method of color determination is necessary. A standard device for the measurement of color has been described in detail by Dorothy Nickerson, Color Technologist of the Bureau of Agricultural Economics (21). Based on the Munsell color system, this method has been used extensively in grading agricultural products, notably cotton and other textiles, hay, cereals, canned foods, and meats, and is readily adapted to color determination in canned peas.

It is therefore apparent from a review of the canning literature, that there are still many questions to be answered concerning the home canning of peas. Important among these pro-

blems is that of determining which methods and periods of processing result in a minimum of spoilage, produce peas of desirable quality, and are at the same time practicable. In Montana where many localities have elevations of several thousand feet above sea level, this problem is of special significance. The effect of altitude in lowering the boiling point of water makes satisfactory preservation more difficult and emphasizes the need for a detailed investigation and comparison of the value of various canning procedures.

EXPERIMENTAL PROCEDURE

Two varieties of peas, Laxtonian and Davis' Perfection, were used in this experimental work. Laxtonian peas were available during both seasons, 1931 and 1932, and peas of the Perfection variety were also canned in the summer of 1932. The Laxtonian is a variety known principally as a garden pea and is used chiefly for home consumption and home canning. The Perfection pea is one of the sweet, wrinkled varieties raised rather extensively for commercial canning.

The preparation for canning and the actual processing was done in the laboratory of the Home Economics department of the Montana Experiment Station. The peas were canned as soon as possible after picking and in all cases the canning was done on the same day in which the peas were harvested.

The peas were shelled by hand, with the exception of the Perfection peas which were shelled by machine in the field. The shelled peas, after being thoroughly washed, were precooked in small lots by boiling for five minutes. While hot, they were packed into glass pint jars. Three kinds of jars were used:- Kerr jars with the all metal lids supplied with a cement ring for sealing; Presto with glass top and rubber ring held in place by a metal ring; and the "Atlas" E-Z Seal jars with a glass top, rubber ring, and metal clamp. The liquid level of the filled jars was uniformly one-half inch from the top. During the first season all jars were completely sealed before processing. Since an undesirable loss of liquid occurred in the canning procedure of the first year, and since it seemed possible that the internal pressure caused by complete sealing might bring about loss of liquid, it was decided that all jars in the second season were to be partially sealed. Partial sealing means that the jars were completely sealed and then the metal ring was given a quarter turn backward to slightly loosen the lid.

Throughout each of the successive canning seasons three general methods of processing were employed:- steam pressure cooker, oven and water bath.

Processing under pressure was done in a National steam pressure cooker of the eighteen-quart size. The amount of

water used, two cups, was just sufficient to cover the rack in the bottom of the cooker. Heat was supplied by a 1200-watt Calrod plate of a Hot Point electric range. When the water reached the boiling point eleven pint jars of hot peas were placed in the cooker in two layers with an open rack between. After the cover was adjusted, steam was allowed to escape in a steady stream for five minutes before the petcock was closed. The steam pressure was then allowed to accumulate until the temperature within the cooker was 240° F. At sea level 240° F. is the temperature comparable to a steam pressure of 10 pounds. At higher altitudes, such as the approximate elevation of 5000 feet at which this experimental work was conducted, a correction must be made in the amount of steam pressure required to produce an internal temperature of 240° F. Since the atmospheric pressure at the 5000 foot altitude is about 12.2 pounds per square inch, while at sea level the pressure is 14.7 pounds, the difference of 2.5 pounds must be added to the steam pressure of 10 pounds, making a total pressure of 12.5 pounds. This is necessary for the reason that the standard pressure gauge is so constructed that it records only that internal pressure which exceeds the external atmospheric pressure. The processing period then begins at the time when the pressure gauge reaches 12.5 pounds.

Oven canning was done in a Hot Point electric oven with