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THE RELATION BETWEEN QUALITY AND
CHEMICAL COMPOSITION OF
CANNED SAUERKRAUT

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ABSTRACT

AN examination for quality and comparison with chemical composition has been made upon 332 samples of commercial canned kraut obtained from packers thruout the country.

The study has shown certain relationships particularly between quality and salt, acid, or vitamin C content; and between the texture of kraut and the salt content. In general, the samples of poorer quality kraut have shown some abnormality in chemical composition, many of them containing less than the required 1.0 per cent of acid, or more than 2.5 per cent or less than 1.5 per cent salt. The better samples of kraut showed a higher average vitamin C content.

The samples of kraut showing high or low percentages of salt were more often soft while those containing between 1.5 and 2.5 per cent were of firm texture. Comparisons of determinations of the salt content as obtained by titration and by salometer readings have shown that the salometer is not suitable for measuring the salt content of sauerkraut.

THE RELATION BETWEEN QUALITY AND CHEMICAL COMPOSITION OF CANNED SAUERKRAUT

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INTRODUCTION

THE consuming public is always anxious to obtain a wholesome food product of the best quality possible. Likewise, most producers or manufacturers of food products are just as anxious to offer high grade foods since it is easy to maintain a ready and continued sale for these products. In most cases this desire is handicapped only by lack of knowledge as to what constitutes a high grade product.

Fermented foods have in the past varied considerably in quality because controlling factors in the fermentation have not always been understood. This was true of sauerkraut. However, since investigations by Peterson, Fred, and co-workers² and by Pederson³ have given a greater knowledge of changes that take place in the fermentation of cabbage into sauerkraut, the type of sauerkraut which will

¹The author acknowledges the assistance of the Misses Eleanore Heist, Mary Hawkes, and Katherine Wheeler and James Moyer in making the chemical analyses discussed in this paper.

²Brunkow, O. R., Peterson, W. H., and Fred, E. B. A study of the influence of inoculation upon the fermentation of sauerkraut. *Jour. Agr. Res.*, 30, 955-960. 1925.

Priem, L. A., Peterson, W. H., and Fred, E. B. Studies of commercial sauerkraut with special reference to changes in the bacterial flora during fermentation at low temperatures. *Jour. Agr. Res.*, 34, 79-95. 1927.

Keipper, C. H., and Fred, E. B. The micro-organisms of cabbage and their relation to sauerkraut production. *Jour. Bact.*, 19, 53. 1930.

³Pederson, C. S. Floral changes in the fermentation of sauerkraut, *New York State Agr. Exp. Sta. Tech. Bul. No. 168*. 1930.

———. The effect of pure culture inoculation on the quality and chemical composition of sauerkraut. *New York State Agr. Exp. Sta. Tech. Bul. No. 169*. 1930.

be produced in a fermentation can almost be predicted from a knowledge of conditions. Conversely, a chemical and organoleptic examination of sauerkraut will often reveal the conditions under which the kraut was produced. If such information is properly presented, the nature of good kraut is revealed and the food offered for consumption can be improved.

The following studies were made upon samples of commercially canned kraut obtained from a majority of kraut packers in the country. The results given are a compilation of analyses made from 332 samples of kraut manufactured during 1932, 1939, and 1940.

METHODS OF ANALYSES

The cans of kraut were given a code number when received and the identification labels removed. Vacuum readings were taken upon the 1940 series. From the 1939 and 1940 series, samples of juice were taken for determinations of the ascorbic acid (vitamin C) content, using the method of Bessey and King⁴ as modified by Mack and Tressler.⁵ The drained weight was determined, then the juice poured back over the kraut and the quality and physical characteristics judged, the points considered being length and fineness of cut, presence of uncut, coarse or large leaves, texture, color, odor, and finally, flavor. No attempt was made to give a numerical score or to grade the samples, but rather to classify them on the basis of quality into five general groups. The obvious defects noted were recorded to see whether any relationship to chemical analysis could be found.

The juice was then expressed from the kraut with the help of a screw press and chemical analyses for salt, total acid, volatile acid, and alcohol were made. Non-volatile acid was calculated by the difference between the volatile and total acid. The ratio of volatile to non-volatile acid was also calculated. Methods used were those previously described by Pederson and Kelly.⁶ Salometer readings of juices of the 1940 series were obtained for comparison with the salt content.

⁴Bessey, O. A., and King, C. G. The distribution of vitamin C in plant and animal tissues, and its determination. *Jour. Biol. Chem.*, 103, 687-698. 1933.

⁵Mack, G. L., and Tressler, D. K. Vitamin C in vegetables. VI. A critical investigation of the Tillmans method for the determination of ascorbic acid. *Jour. Biol. Chem.*, 118, 735-742. 1937.

⁶Pederson, Carl S., and Kelly, C. D. Accuracy of Certain Methods Used in Analysis of Sauerkraut. *Food Res.*, 1, 277-286. 1936.

RESULTS AND DISCUSSION

Obviously the presentation of the results of the analyses of the 332 samples⁷ becomes valuable only when the relationships between the various analyses are studied and compared with quality. Such relationships are shown in Figs. 1 to 11.

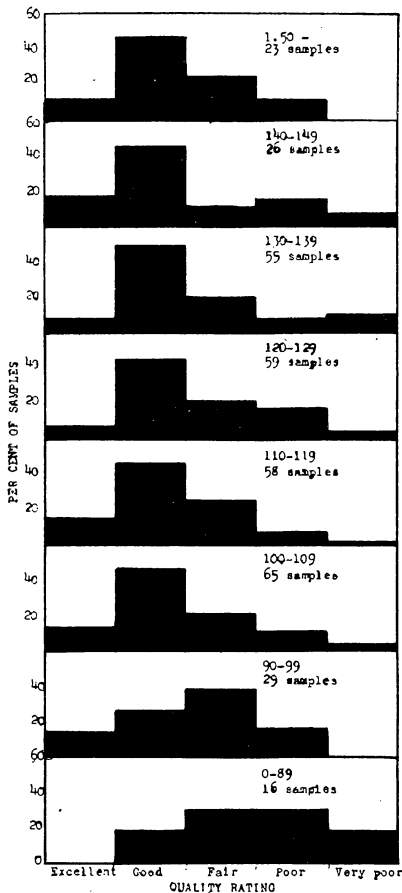


FIG. 1.—THE RELATION BETWEEN TOTAL ACIDITY AND THE QUALITY OF KRAUT, SHOWING THE RATING BY PER CENT OF SAMPLES WITHIN EACH ACID RANGE.

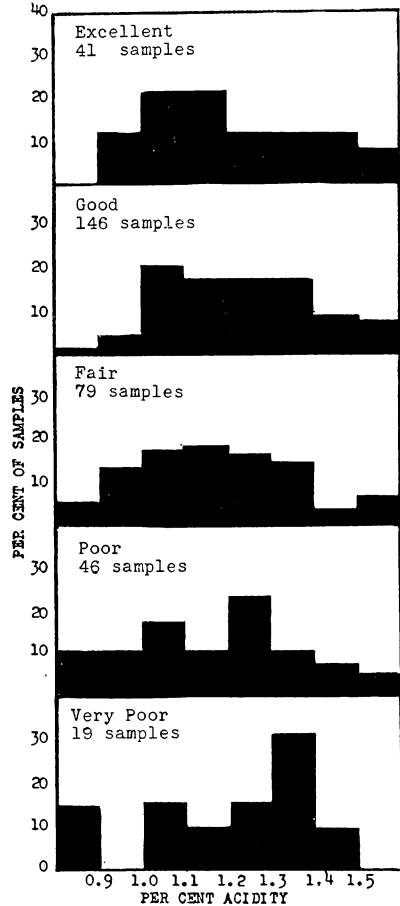


FIG. 2.—THE RELATION BETWEEN THE QUALITY AND THE ACIDITY OF KRAUT, SHOWING THE ACIDITY BY PER CENT OF SAMPLES WITHIN EACH QUALITY RANGE.

⁷The detailed analytical data will be found in Mimeograph Bulletin No. 3 of this Station, a copy of which may be obtained on request.

Total acid and quality.—The most common chemical test made on kraut is that of total acid. Present government standards require 1.0 per cent acid calculated as lactic acid in canned kraut, but in ordinary fermentations the natural acid produced is usually well above 1.5 per cent and often above 2.0 per cent. In the canning process this acidity is reduced somewhat by the necessary addition of water. Because of the common complaint of consumers and buyers that kraut is too sour, this is often diluted still more. Occasionally, dilution with water is made for other purposes.

The majority of krauts were found to contain between 1.0 and 1.4 per cent acid (Fig. 1). Occasionally high grade kraut contained less than 1.0 per cent acid, but seldom do these higher quality products show less than 0.90 per cent acid. On the other hand, among the poorer krauts, the percentage of samples containing less than 1.0 per cent acid is considerably higher. Results are also presented (Fig. 2) to show the relationship between acidity and quality. Presented in this way it is clearly seen that the less acid kraut is in general, poorer in quality, but when the kraut contains more than 1.0 per cent acid, little difference is observed. This may be due to a failure of the cabbage to ferment in certain cases, while in other cases it may be due to faulty fermentation and attempts by packers to reduce off-flavors by washing or dilution of the kraut. Regardless of the fact that good and excellent quality kraut may be obtained with less than 1.0 per cent acid, the food value of such kraut is reduced by addition of water.

Volatile acid and quality.—In a normal fermentation of sauerkraut a small but more or less constant quantity of acetic acid (volatile acid) is formed. In certain abnormal fermentations, the amount of this volatile acid may be lessened while in others it may be increased. In the latter type of abnormal fermentation, even a little butyric acid may be produced.

Normally good or excellent canned kraut usually contains from 0.15 to 0.30 per cent volatile acid (Fig. 3), with occasional samples showing as much as 0.37 per cent. On the other hand, a somewhat higher percentage of samples show volatile acid contents above or below the limits among the poorer products. These abnormalities are reduced generally by the dilution used in canning. Occasionally these abnormal fermentations are revealed more distinctly by calculating the ratio between the volatile acid and the non-volatile acid (Fig. 4). Normal ratios are between 0.20 and 0.30, but variations

from these figures are greatest among the poorer quality products, three samples showing ratios above 0.50.

Alcohol and quality.—In a normal fermentation of sauerkraut a small percentage of the sugar is converted to alcohol. The amount of alcohol produced is fairly constant but in dilution and in the heating of the canning process, this amount is reduced to 0.10 to 0.30 per cent (Fig. 5). In certain fermentations an abnormal amount of alcohol is produced particularly where yeasts are allowed to develop. Not only does excessive yeast growth produce alcohol but

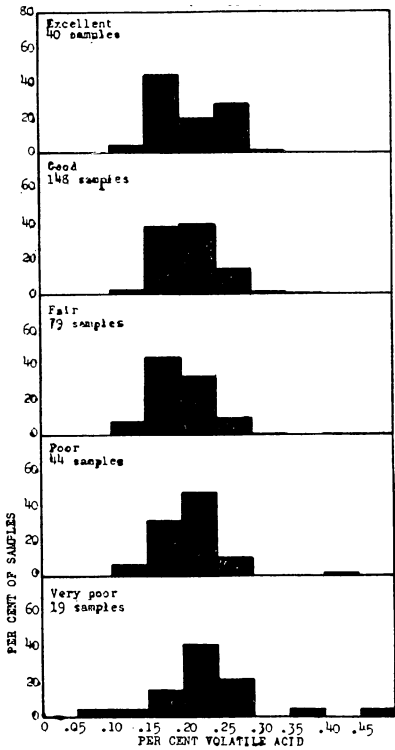


FIG. 3.—THE RELATION BETWEEN THE QUALITY AND THE VOLATILE ACIDITY OF KRAUT, SHOWING THE VOLATILE ACIDITY BY PER CENT OF SAMPLES WITHIN EACH QUALITY RANGE.

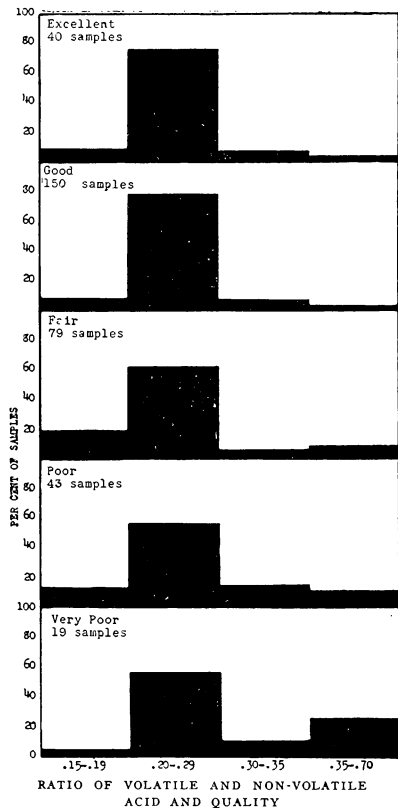


FIG. 4.—THE RELATION BETWEEN THE QUALITY AND THE RATIO OF THE VOLATILE TO THE NONVOLATILE ACIDITY, SHOWING THE RATIO BY PER CENT OF SAMPLES WITHIN EACH QUALITY RANGE.

it also results in a putrid kraut. The results of analysis show (Fig. 5) that the incidence of high alcohol content is greater among the poorer krauts than among the higher quality products. On the other hand, since the alcohol content of kraut may be changed so much during the processing, the amount present can seldom be used as a criterion of quality.

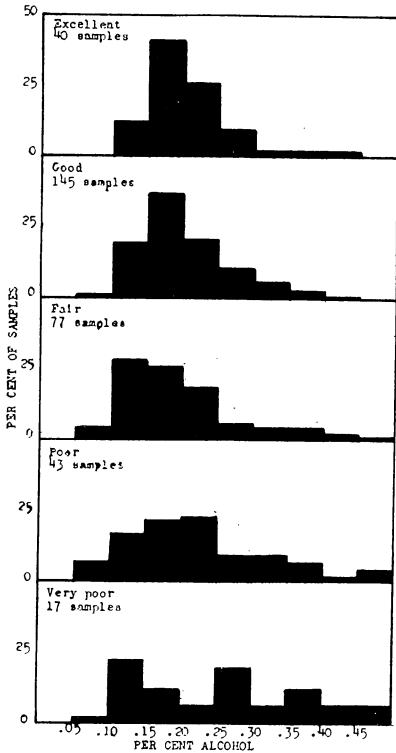


FIG. 5.—THE RELATION BETWEEN THE QUALITY AND THE ALCOHOL CONTENT OF KRAUT, SHOWING THE ALCOHOL BY PER CENT OF SAMPLES WITHIN EACH QUALITY RANGE.

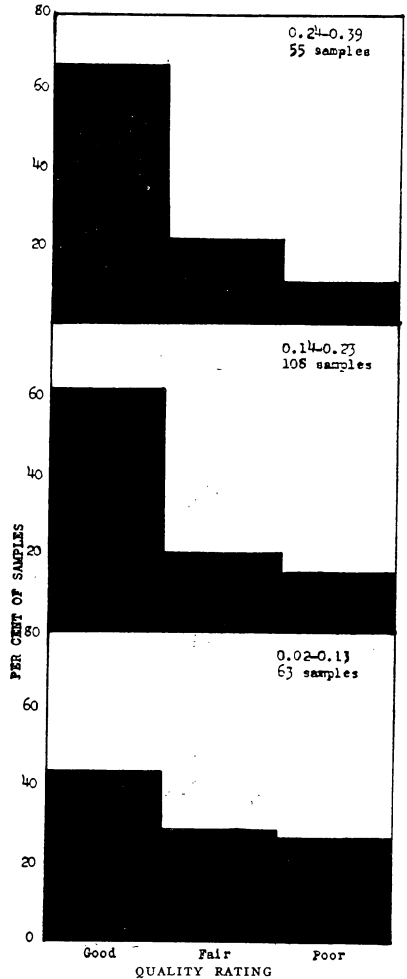


FIG. 6.—THE RELATION BETWEEN THE ASCORBIC ACID (VITAMIN C) CONTENT AND THE QUALITY OF KRAUT, SHOWING THE QUALITY RATING BY PER CENT OF SAMPLES WITHIN THREE ASCORBIC ACID CONTENT RANGES.

Vitamin C (ascorbic acid) and quality.—It has been known for a long time that sauerkraut has certain antiscorbutic value. It has also been noted by Clow, *et al.*,⁸ and Parsons⁹ that samples of kraut vary in the amount of vitamin C present. The effect of fermentation and processing on vitamin C has been shown by Pederson, *et al.*;¹⁰ hence, the vitamin C content of the samples of kraut examined in 1939 and 1940 was determined. The analyses showed contents of ascorbic acid (vitamin C) which varied from 0.00 to 0.39 mgms. per gram of sauerkraut, the majority of samples containing between 0.14 and 0.23 mgms. (Figs. 6 and 7.) Approximately one-fourth of the samples contained more than 0.23 mgms. and one-fourth contained less than 0.14 mgms. Further examination of this data shows that in general the higher quality products contain the larger amount of vitamin. There is considerable variation from this in that some of the poorest kraut contained the most vitamin C. From the results it may be assumed in general that a high grade kraut that has not been diluted too much in canning is comparatively high in ascorbic acid.

Salt and quality.—The amount of salt added to kraut and the method of adding salt are perhaps the greatest variables met with in the making of sauerkraut. Apparently, German makers used small amounts of salt in some cases. Until recently, many packers used rule of thumb methods or a salometer test in making kraut, but relatively few determined the exact amount of salt in the kraut. Government standards at present specify 2 to 3 per cent as the correct amount of salt to use in kraut. It has been found that when the salt content is much above 2.5 per cent, the activities of desirable types of bacteria are inhibited, and this in turn allows a more active growth of certain pink yeasts, according to Fred and Peterson¹¹ and Pederson and

⁸Clow, B., Parsons, H. T., and Stevenson, I. The vitamin C content of commercially canned sauerkraut, together with some observations on its vitamin A content. *Jour. Agr. Res.*, 41, 51-64. 1930.

———, Marlatt, A. L., Peterson, W. H., and Marten, E. A. The vitamin C content of fresh sauerkraut and sauerkraut juice. *Jour. Agr. Res.*, 39, 963-971. 1929.

⁹Parsons, H. T. The vitamin C content of sauerkraut and how it is determined. *Canning Trade*, 52, 39, 16-18. 1930.

¹⁰Pederson, C. S., Mack, G. L., and Athawes, W. L. Vitamin C content of sauerkraut. *Food Res.*, 4, 31-45. 1938.

¹¹Fred, E. B., and Peterson, W. H. The production of pink sauerkraut by yeasts. *Jour. Bact.*, 7, 257. 1932.

Kelly.¹² Still higher amounts of salt may stop entirely the growth of the lactic acid producing bacteria.

In these analyses it was found that the majority of canned krauts contained between 1.5 and 2.5 per cent salt (Fig. 8), but certain samples contained as much as 3.4 per cent and others as little as 0.7

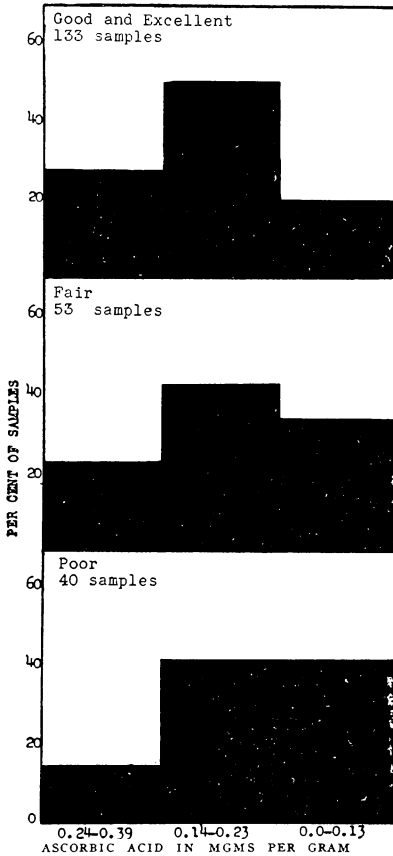


FIG. 7. — THE RELATION BETWEEN QUALITY AND ASCORBIC ACID (VITAMIN C) CONTENT OF KRAUT, SHOWING THE ASCORBIC ACID CONTENT BY PER CENT OF SAMPLES WITHIN EACH QUALITY RANGE.

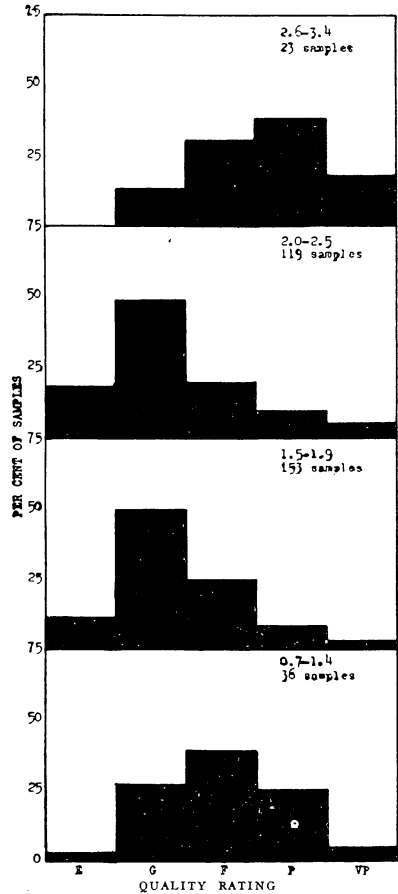


FIG. 8.—THE RELATION BETWEEN THE SALT CONTENT AND THE QUALITY OF KRAUT, SHOWING THE RATING BY PER CENT OF SAMPLES WITHIN EACH SALT RANGE.

¹²Pederson, C. S., and Kelly, C. D. Development of pink color in sauerkraut. *Food Res.*, 3, 583-587. 1938.

per cent. Of course it is well known that this does not represent a proportional amount of salt to that added, since some canners add salt brines in canning while others add pure water.

No single factor has as direct a relation to quality of kraut as the salt content. Well over 60 per cent of the samples found to contain between 1.5 and 2.5 per cent salt were rated as good or excellent quality krauts (Figs. 8 and 9). On the other hand, only 3 of 23 samples containing more than 2.5 per cent salt were rated good or better and only 11 of 36 samples containing less than 1.5 per cent salt were rated as good or better. The percentage of poor and very poor kraut was very high, among these two latter groups. A study (Fig. 9) shows that a high percentage of the poor and very poor krauts did not contain 1.5 to 2.5 per cent salt. Well over 90 per cent of the samples rating good or excellent contained between 1.5 and 2.5 per cent salt.

Salt and texture.—A further interesting relation exists between the salt content and the texture of kraut. Of the 118 samples containing between 2.0 and 2.5 per cent salt, only 10 samples were soft in texture while 68 per cent were firm (Fig. 10). Those samples containing more than 2.5 per cent or less than 1.5 per cent showed a high percentage of soft krauts.

These results show that the kraut packer would obtain better kraut if he was more careful in salting. Unfortunately, many kraut packers still depend upon a salometer for determining the amount of salt in kraut. The faults of this instrument for making analyses of kraut were shown by Pederson and Kelly.¹³ In the

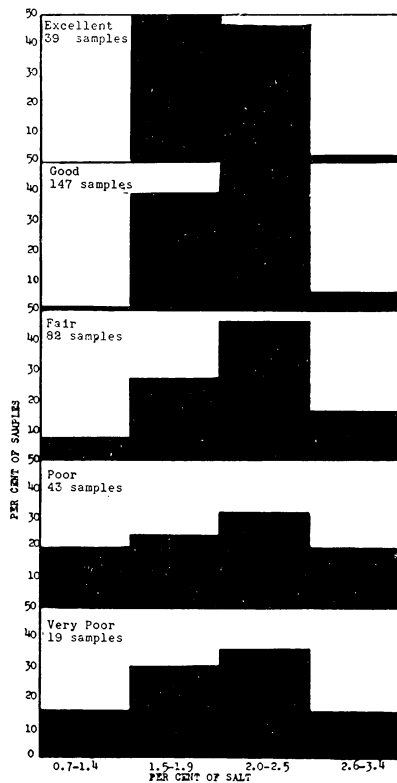
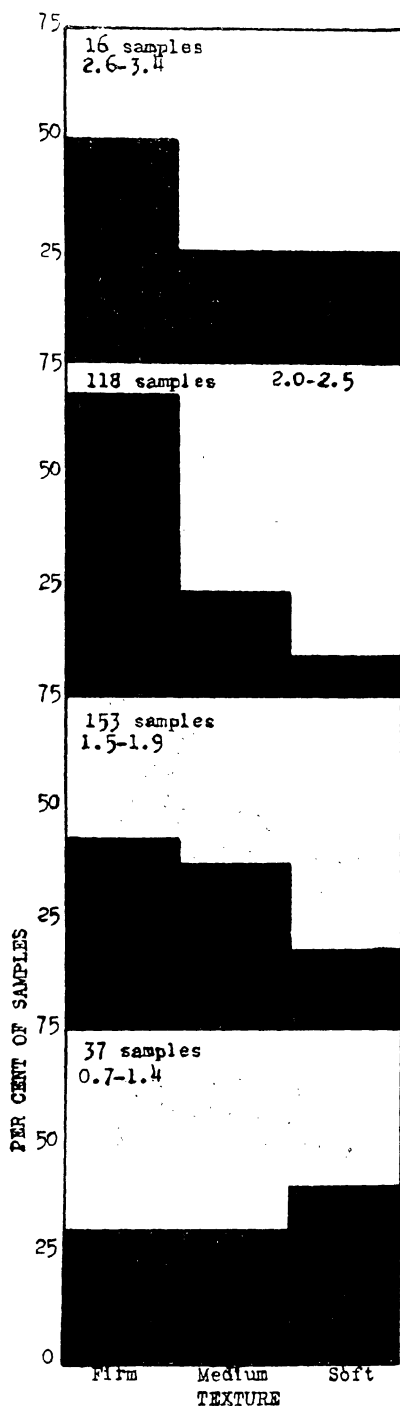


FIG. 9.—THE RELATION BETWEEN THE QUALITY AND THE SALT CONTENT OF KRAUT, SHOWING THE SALT CONTENT BY PER CENT OF SAMPLES WITHIN EACH QUALITY RANGE.

¹³See footnote 6.



1940 series of 154 samples, salometer readings at 60° F were obtained upon the juice expressed from the samples. A comparison of these readings with the actual salt contents as determined by titration with silver nitrate solution show (Fig. 11) only a general relationship between the two. Differences as great as 1.35 per cent salt were obtained between two samples testing 16 salometer. Any number of similar irregularities could be pointed out which show the entire unsuitability of this instrument for use in determining salt in sauerkraut.

The ideal chemical analysis.— From the foregoing results and discussion it can be seen that no one chemical test can be used to separate poor from good quality kraut. The data may be used in establishing the ideal composition of kraut as shown in Table 1, but many samples of good kraut may be out of the limits set in certain respects while occasional samples of poor kraut come within the range. It is necessary, therefore, to broaden this ideal analyses to what might be called permissible analyses. If the analyses of the 332 samples of kraut are now considered in relation to these ideals, it is noted that even tho no one analysis is selec-

FIG. 10.—THE RELATION BETWEEN THE SALT CONTENT AND THE TEXTURE OF KRAUT, SHOWING THE TEXTURE BY PER CENT OF SAMPLES WITHIN EACH SALT RANGE.

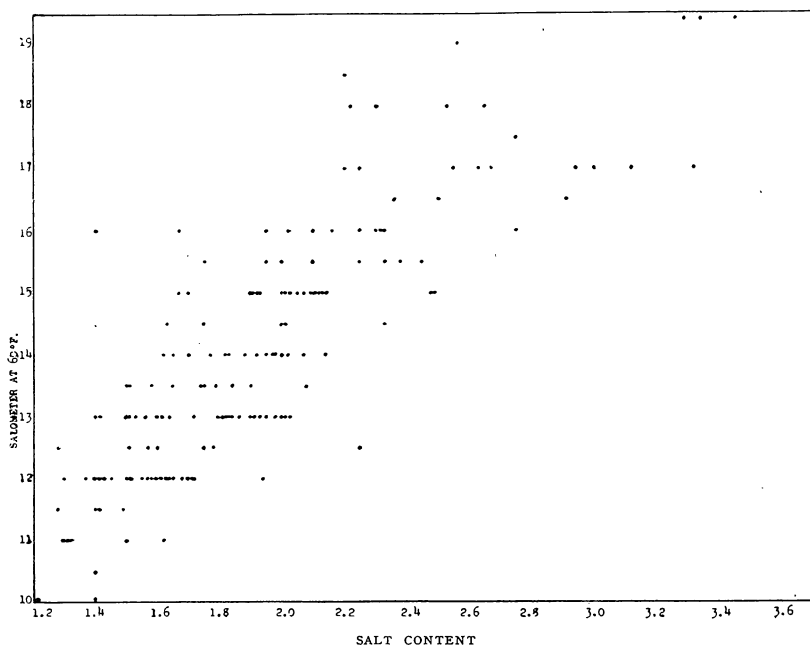


FIG. 11.—THE RELATION BETWEEN THE SALOMETER READING AT 60° F AND THE ACTUAL SALT CONTENT OF JUICES OF CANNED KRAUT AS DETERMINED BY TITRATION.

tive in separating poor from good kraut, collectively a fair degree of separation may be effected. From Table 1 it is noted that only 20 per cent of the samples rating good or better show variations from this permissible analysis. In contrast, 46 per cent of the samples rating fair and 67 per cent of the samples rating poor show analyses varying from this normal.

If the controllable factors salt and acid are considered, it is found that 85 per cent of the good and excellent quality krauts contain the permissible amount of salt and acid, while 63 per cent of the fair krauts and 44 per cent of the poor krauts contain more than 1 per cent acid and between 1.5 and 2.5 per cent salt. The remaining 15 per cent of good and excellent krauts which vary from this permissible analysis did so only slightly, that is, the highest salt was 2.6 per cent and the lowest acidity was 0.83 per cent. In contrast, these variations were greater among the poorer krauts, one sample con-

TABLE I.—THE AVERAGE CHEMICAL COMPOSITION AND VARIATION FROM THE AVERAGE OF SAMPLES OF CANNED KRAUT.

	TOTAL ACID RANGE, PER CENT	VOLATILE ACID RANGE, PER CENT	RATIO RANGE	ALCOHOL RANGE, PER CENT	SALT RANGE, PER CENT	ASCORBIC ACID, MGMS. PER GRAM	TOTAL PER CENT OF SAMPLES NOT WITHIN RANGE
Ideal analysis.....	1.1-1.5	0.15-0.30	0.20-0.30	0.15-0.25	1.7-2.4	0.15 and up	—
Permissible analysis.....	1.0-up	0.10-0.30	0.15-0.35	0.10-0.35	1.5-2.5	0.10 and up	—
Number of Samples Above or Below Permissible Analysis							
	Above	Above	Be- low	Above	Above	Above	Be- low
Good kraut 190.....	19	4	—	7	2	—	20
Fair kraut 79.....	14	3	—	7	7	—	46
Poor kraut 63.....	13	3	1	9	11	—	67

taining only 0.40 per cent acid and another containing 3.4 per cent salt.

Other analyses.—Certain analyses and observations have been given little consideration, namely, vacuum, length of cut, color, and odor. Too few low vacuum readings were obtained to give any significant data. A long cut kraut of course is desirable from the standpoint of appearance but makes little or no difference as far as the quality or nutritive value is concerned. The color and odor are very important in determining the quality of kraut. Little need be said about the latter factor. A few of the samples were so abnormal in color that they might be considered very poor kraut on that basis alone.

Comparison of the samples of kraut packed in 1931 and 1932 with those of 1939 and 1940 shows a slight superiority for the latter samples over the former and also a tendency to vary less from the ideal analyses previously mentioned.

SUMMARY

Three hundred and thirty-two samples of canned sauerkraut have been analyzed to determine their quality and chemical composition.

The better quality krauts showed more constant amounts of acids, salt, and alcohol than do poorer quality products and, in general, contained more vitamin C.