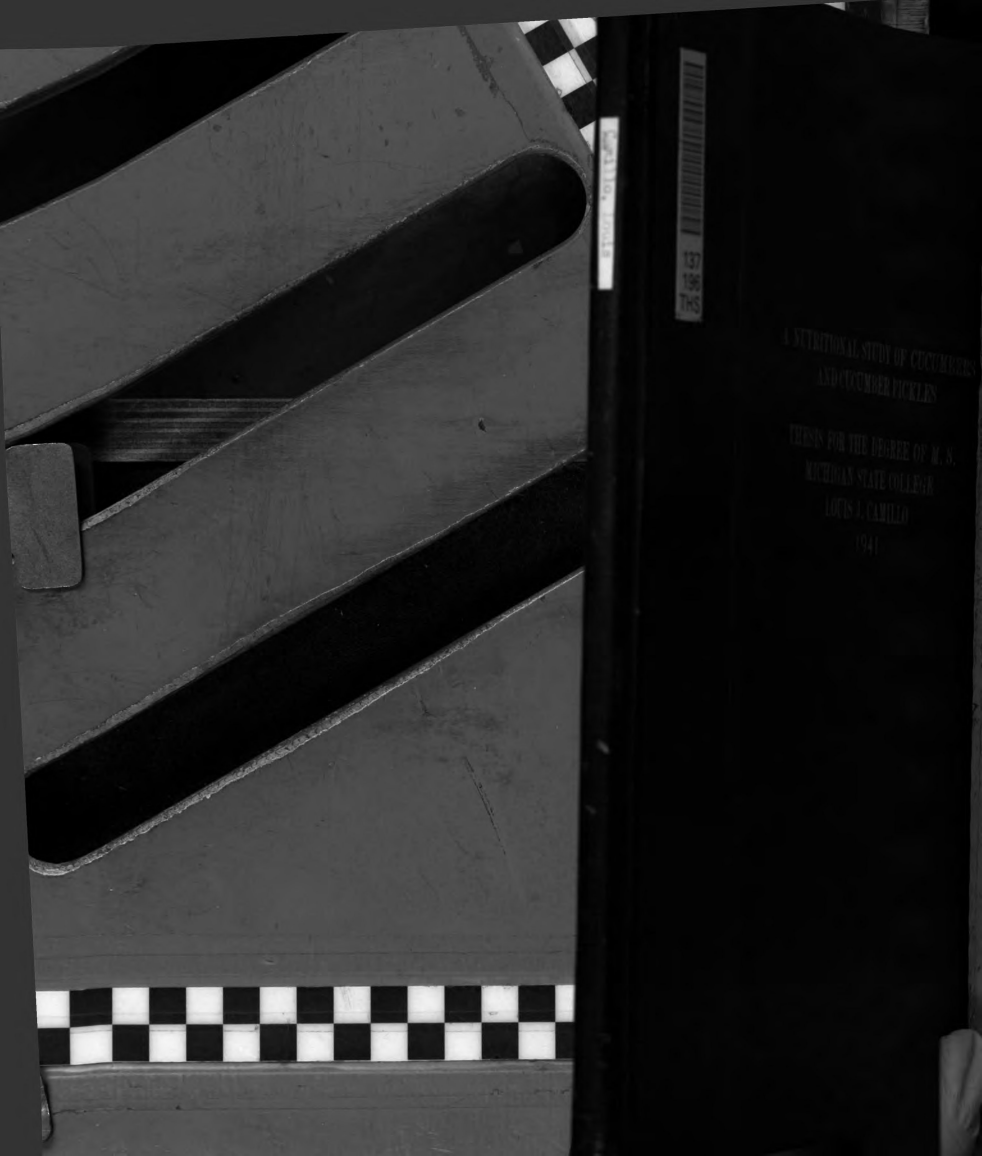

A NUTRITIONAL STUDY OF CUCUMBERS AND CUCUMBER PICKLES

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Introduction

One of the important fields in biochemistry is that of nutrition. The chemical analysis of foodstuffs both for human and animal consumption has produced valuable information regarding their nutritional value. Much research has been done on the study of sources of protein, essential elements, vitamins, fats, and carbohydrates. It is only by analizing the entire list of edible foods that our information can be complete. There is very little information on cucumbers and less on the various kinds of pickles made from them. In view of the fact that pickles form a part of the diet, it was considered desirable to make a chemical and biochemical analysis of them in order to ascertain their nutritional value.

Review of Literature

Carbohydrates. Among the first to determine the carbohydrate content of cucumbers was Myers and Croll (25). They found the per cent of total sugars (reducing and non-reducing) of cucumbers to average 3.39. Their results showed that the amounts of soluble sugar for most fruits and vegetables compared favorably with the amount of total carbohydrate indicating that the percentage of starch is small in fruits and many vegetables.

Bell, Long, and Hill (3) found that the amount of available carbohydrate in cucumbers was 1.7 per cent.

Kitahara (22) studied the changes in the chemical components of cucumbers during the ripening process. His results showed that the quantity of carbohydrates increased until the tenth day after bloom and then decreased. The amount of ash, fiber, and protein decreased slowly after bloom and thereafter remained unchanged. The cucumbers contained 0.5 per cent glucose and 0.4 per cent fructose, the principal sugars present, and a trace of sucrose.

In 1939 H. J. Heinz Company (30) published the results of analayses carried out by their research department of a large number of vegetables and vegetables products. Their results for the carbohydrate content of fresh cucumbers and pickle products made from cucumbers were as follows: Fresh cucumber 3.1 per cent, sour pickles 1.3 per cent, fresh cucumber pickles 15.9 per cent, sweet mustard pickles 25.3 per cent, and sweet pickles 34.0 per cent.

Fat. Einhom, Milski, and Kolashnikov (12) determined the fat constants of oil, which was obtained by the extration of finely ground air-dry cucumber seeds with ether. They also determined the solidifying point, free acids, non-saponifiable, and per cent glycerol. The acids consisted of oleic, linoleic, palmitic, and stearic in decending order of quantity. The Rosenheim Webster test for vitamin A showed one-fifth as much of this vitamin present in cucumber seeds as in fish oil. The whole seed analysis showed the following percentages: moisture 8.0, oil 31.47, protein 29.69, carbohydrate 1.88, pectins 0.59, ash 3.92, P_2O_5 in

ash 2.25. The oil and the press cake were high in nutritive value. Toyama and Tsuchiya (41) found that the amount of kernel oil in twenty samples varied from 42 to 78 per cent and that of the ether extracted kernel oil from 39.7 to 49.2 per cent. Only small amounts of trichosanic and linolenic acids were found in the oils. The following figures are the per cent by weight of fat secured by Heinz (30) for cucumbers and various cucumber pickle products: cucumber 0.2, sour pickles 0.2, fresh cucumber pickle 0.2, sweet pickles 0.2, sweet mustard pickles 0.4.

Protein. Oparin (26) made crystalline preparations of globulins from cucumber seeds by the Osborne Method. The per cent of free amino nitrogen as obtained by Van Slyke's method from the above preparation was 2.69.

Yashimura and Nishida (47) obtained 0.27 grams of adenine hydrochloride and 0.5 grams of trigonelline aurichloride and a trace of arginine from a hot water extract obtained from 22 kilograms of cucumbers.

Heinz (30) showed that the protein content of cucumbers and pickle products made from them was as follows: cucumber 0.8 per cent, fresh cucumber pickles 1.2 per cent, sour pickles 0.9 per cent, sweet pickles 0.7 per cent, and sweet mustard pickles 1.4 per cent.

Vitamin A. Jansen and Donath (20) tested various foods for their value as sources of vitamin A and protein, using a

curative method. Rats were fed a diet of polished rice and given a supplement of different foodstuffs. From the results obtained they made a classification of the various foodstuffs with respect to vitamin A. The first group contained foodstuffs very rich in vitamin A of which the addition of from 1 to 5 per cent of them on the dry basis was sufficient to supplement satisfactorily a vitamin A-free basal diet. One of the vegetables included in this group was fresh cucumbers which required from 5 to 10 grams. In the second group was included those foods having so little vitamin A as to be insufficient to prevent a symptoms of vitamin A deficiency when used exclusively. An example of this was rice (polished and unpolished).

Heinz (30) found the vitamin A content of cucumbers to be 35 International units per 100 grams.

Vitamin B_1. Heinz (30) who were the only ones to do work on vitamin B_1 in cucumbers, found them to contain 30 International units per 100 grams.

Vitamin B_2 or G. Teng-Yi Lo (23) working with four varieties of cucurbits found that cucumbers were a relatively good source of vitamin B_2, while muskmelons were deficient in this vitamin.

Heinz (30) give the vitamin B_2 content of cucumbers as 60 International units per 100 grams.

Vitamin C. Embrey (13) found that the feeding of 10 grams daily of cucumber, chico, pomelo, and guana protected guinea pigs from scurvy for nine weeks, while 15

grams daily of banana, kangkong leaves, and kamate leaves were essential for similar protection. Incomplete experiments with lansones indicated that 10 grams daily were evidently insufficient as a protection from scurvy.

Thurman and Vahlteich (40) also fed fresh cucumbers and fresh cucumber pickles of the bread and butter type to guinea pigs and found that they were protected against scurvy, the pickles apparently having the same antiscorbic potency as fresh cucumbers. The pickles made from salt stock cucumbers failed to protect from scurvy.

Fujimaki, Shimoda, and Saiki (33) preserved cucumber and egg plant in "nukamiso" (paste made from rice polishings) and found them to contain a small of vitamin C. Chao-Yu Chen (9) by preventive and curative experiments showed that cucumber, melons, fresh dates, and lotus root, contained appreciable quantities of vitamin C. Later (8) he found that 10 grams of fresh cucumbers protected guinea pigs from scurvy.

Chen and Chen (10) likewise found that cucumbers possessed antiscorbutic properties.

Yarusova (45) showed that 12 grams of fresh cucumbers daily provided the minimun prophylactic dose of vitamin C for a guinea pig. Pickled cucumbers were devoid of this vitamin. He (46) also worked with salted cucumbers and dried carrots as vitamin C carriers. It was estimated that the antiscorbutic activity of fresh cucumber was not less than 80 units per kilogram (80 to 160 International units)

while salted cucumbers purchased on the market contained practically no vitamin C.

E. Caserio (6) compared lemon juice with cucumbers, sour jujubes, and the berries of mountain ash and found that fresh cucumbers contained less vitamin C than the lemon juice.

A practical method has been worked out for the determination of the ascorbic acid content of vegetable matter by Spruyt and Donath (35), by means of enzymic action. This is called the ascorbic-acid-oxidase method and the results obtained agree with values previously found.

Total and reduced vitamin C were determined in various plant and animal tissues by Fujita and Ebihara (16). In animal tissues vitamin C was found chiefly in the reduced form over 80 per cent, whereas in blood over 95 per cent is in dehydro-form (oxidized). In plants it is present also to a large extent as the dehydro form. They found that cucumbers contained much more vitamin C in the skin and chiefly in the dehydro form. In the fresh state, vegetables contained more vitamin C in the reduced form.

Gomolyako (18) showed that there was from 5 to 19 milligrams per 100 grams of vitamin C in cucumbers and garlic.

Vitamin C was also determined by the 2,6-di-chloro-phenol-indo-phenol method by Barron (2). The average content in milligrams per cent was 40 for cucumbers.

The vitamin C content of cucumbers was placed at 2.8 to 9 milligrams per cent by Schatzlein and Fox-Temmling (32)

According to Heinz (30) cucumbers contained 200 International units per 100 grams.

Products of Acid Fermentation. Kalmuikov (21) working with dogs found that pickle juice, krass and sauerkraut juice were strong stimulants for the stomach glands.

Rojahn, Filss, and Wirth (31) emphasized the importance of crude plant juices, carrots, tomato, cucumber etc., in the general dietary and in the treatment of certain deseased conditions.

Pectins. Very little work has been done on the pectin content of cucumbers or pickles. Fabian and Johnson (14) studied the pectin content of normal and decomposed pickles. The per cent of total pectic materials as calcium pectate in normal pickles on the dry weight basis was 16.28 in the alcohol insoluble material and 13.0 per cent of the total dry matter. The soluble pectic material as calcium pectate in normal pickles on a fresh weight basis was 0.53 per cent.

Glutathione. 34 to 340 micrograms of glutathione per 100 grams of fresh material were found in the fruit of papaya, cucumber, and pineapple by Ganapathy and Sastri (17). It constituted 5 to 10 per cent of the total -SH compounds.

Crude Fiber. Heinz (30) gives the per cent by weight of crude fiber in cucumber as 0.7.

Enzymes. Thunberg (38) showed that a phosphate extraction

of cucumber seeds contain a variety of dehydrogenases, which are utilized for a highly sensitive biological color reaction for citric acid.

An ereptic enzyme was demonstrated in cucumbers by Chopra and Roy (11), with an optimun activity of pH 5.4 to 6.2.

Wagner-Jauregg and Rauen (42) extracted cucumber seeds with KH_2PO_4 and it yielded a solution containing a dehydrogenase which decolorizes methylene blue in the presence of sodium glycerophosphate.

Thunberg (39) obtained phosphate extracts from cucumbers which contained a dehydrogenase (amylodehydrogenase), which could utilize soluble starch, glycogen or dextrin as donators.

Stone (36) demonstrated the presence of ascorbic acid oxidase in cucumbers, and Chakraborty and Guha(7) showed that many plant tissues contained the enzyme ascorbic acid oxidase, the best source being the cucumber.

Calcium. Wilkins (43) grew cucumbers upon soils (unlimed or moderately limed), and at different periods of growth analized samples of the plants for CaO, N, P_2O_5, K_2O, and MgO. Results showed that the calcium content of vines was very high, and increased during growth from three per cent to five or six per cent of the dry weight. The other inorganic plant constituents were lower in the vines than the calcium oxide, but usually higher in the fruit.

Heinz (30) found the calcium content of cucumbers to

be 0.016 per cent.

Tomato and cucumber plants were subjected to ultra violet radiations daily for 5 weeks. Analysis, by Wynd and Fuller (44) showed a definite increase in the calcium content, while the phosphorus content decreased.

Copper to the extent of 2.3 milligrams per kilogram of fresh material was found to be present in the cucumber by Guerithault (19).

Heinz (30) found the amount of copper in cucumbers to be 0.6 milligrams per kilogram.

Iron. The iron content of cucumbers is given as 3.3 milligrams per kilogram by Heinz (30).

Phosphorus. The phosphorus content is given as .033 per cent by Heinz (30).

Other Minerals. Mayrhofer, Schneider, and Wasitzky (24) made biochemical studies on the iodine and fluorine content of cucumbers. Shirahama and Shimiza (34) determined iodine in cucumbers by a modified Leitch-Henderson method, and found it to be 99.4 gammas per 100 grams of dry matter.

Zinc. Zinc was determined in a large number of food products by Bertrand, and Benzon (4) by the calcium zincate method. Expressed in milligrams per kilogram on fresh material and on the dry basis , the values, for cucumbers, obtained were 1.6 and 436 respectively.

The molybdenum content in milligrams per 1000 grams was determined by Ter-Meulen (37) and was found to be 0.01.

Moisture. Yoshimura and Nishida (47) found that the water content of cucumbers was 96.15 per cent.

Present Work

Pickles may be classified under three general types according to Fabian and Switzer (15). Type one is the fermented fresh cucumber pickle as represented by genuine dill pickles. They are made from fresh cucumbers by the addition of salt, with or without acid, dill weed and spices. They are permitted to ferment for three to six weeks after which they are ready to eat.

Type two is the unfermented fresh cucumber pickles in which fresh cucumbers are packed in glass containers and brined with a liqupr consisting of vinegar, with or without sugar, dill weed and spices, in the case of fresh cucumber dills, after which they are pasteurized and ready to eat. The other kind of pickles used in this work which comes under this type is the "bread and butter" pickle.

A third type of pickle is made by salting fresh cucumbers in a heavy salt, (8.8 to 10.6 per cent)(30 to 40 degrees Salometer) brine, and allowing them to ferment for several months or even years after the salt reaches this concentration. When pickles are to be made from this salt stock, the salt is removed by soaking the pickles in several changes of cold and hot fresh water. This is known as "processing". The processed or freshened stock may then be made into "sweet, sour, processed dill pickles,

relish or many other types of pickles or pickle products by the addition of sugar, vinegar, spices, etc. This is known a s "finishing". Sweet pickles and processed dill pickles are representative of this type of pickle.

In this work cucumbers that had been grown on three types of soil, muck, clay, and sandy loam, were analized to determine the influence of the type of soil on their chemical composition. Likewise, analyses were made of genuine dill pickles made from these same lots of cucumbers to determine the influence of the fermentation and subsequent storage on the chemical and biochemical composition. This was done for two successive seasons, 1939 and 1940.

A study was also made of pasteurized dill pickles and bread and butter pickles, as well as the fresh cucumbers from which they were made, to determine the influence of the manufacturing process on their composition and nutritional value.

Analysis were also made of fresh cucumbers, salt and processed stock, and of finished pickles in the form of sweet and processed dill pickles, to study the influence of these various operations on the nutritive value of the pickles.

This work, therefore, includes chemical and biochemical analysis of fresh cucumbers and the influence of the various manufacturing processes through which they pass in order to convert them into pickles. A sufficient

number of varieties of pickles from each general type of pickles was included so as to make the work representative.

Experimental Procedure

Moisture was determined by weighing a ten gram sample of material into a previously weighed crucible and drying for three to four hours at 80 degrees Centrigrade in a vacuum oven until the weight was constant.

Ash was determined by the official method of A.O.A.C. (1) XXVII, 8.

Total Nitrogen was determined by a combination of the Kjeldahl and Gunning methods (1) 11, 21 and 22. A slight modification of the Kjeldahl method was used by distilling the ammonia into a four per cent boric acid solution instead of the standard acid solution, and using a factor of 6.25 to convert the nitrogen into per cent protein.

Crude Fat or ether extract was determined by the official (1) direct method XXVII, 21 and 22.

Simple carbohydrates. The reducing sugars were determined by the offical method (1) as given in XII 2b and 42, XXXIV, 37, 38, and 40.

Carotene. Two different methods were employed for the determination of carotene. In 1939 the Peterson, Hughes and Freeman (29) method was used for determining the carotene contentof the genuine dill pickles packed that year. The photeleometer was used and was equipped

with a blue filter supplied by the Central Scientific Company. In 1940, the method developed by Petering, Wolman and Hibbard (28) was used to determine the carotene content of all the cucumbers and pickles analized. The conversion factor used to change carotene into the vitamin A equivalent was 0.0006 milligrams, the amount of pure beta carotene which possessed activity equal to one International or one United States Pharmacopeial unit of vitamin A.

Vitamin B_1, the antineuritic vitamin, was determined biologically with rats. The standard used for the controls in these experiments was the product made by Jansen of Amsterdam, Holland, which was identical in character and potency with the International Standard.

Vitamin B_2 or G. The growth method with rats was also employed in determining the amount of vitamin B_2 in cucumbers and pickles. The standard used for the contrel feeding experiment was antoclaved brewer's yeast made by Harris.

Vitamin C or the Antiscorbutic vitamin. A chemical method was used for this determination. The material was extracted with a mixture of 16 per cent trichloroacetic and six per cent metaphosphoric acids and titrated with sodium 2,6, di chlorophenol indophenol.

Vitamin D. The vitamin D or antirachitic vitamin was determined according to U.S.P. line test method.

Calcium was determined according to the offical method (1) XII, 10 of the A,O.A.C.

Copper. An unpublished modification by L. Butler of the Michigan State Experiment Station, Chemistry of the

Callan and Henderson method (5) was employed. The colorimeter and also a photelometer was utilized, and the copper concentration was obtained from a previously constructed transmission-concentration curve.

Iron. The titrimetric method (1) XII, 8, of the A.O.A.C. was used for determining the amount of iron present in cucumbers and pickles.

Phosphorus. Phosphorus was determined by slightly modifying the Youngburg method (48) used for blood. The photelometer was used to obtain the phosphorus concentration which were read from a previously constructed transmission-concentration curve.

Influence of Type of Soil on Genuine Dill Pickles

Five bushels of cucumbers that had been grown on each of three different types of soil, clay, muck, and sandy loam, were collected in the middle of the pickle season from a pickle station. Chemical and biochemical analysis were made of a representative sampling of each lot of the fresh cucumbers. The rest were made into genuine dill pickles. The work covered a two year period, 1939 and 1940.

The genuine dill pickles were made in barrels according to the following procedure: About three to four pounds of salt-cured dill weed was placed in the bottom of the barrel and 125 pounds of fresh cucumbers were added.

Another layer of about the same amount of dill weed was added and the barrel filled nearly full of pickles and a final layer of three or four pounds of dill weed added. As the cucumbers were being packed in the barrels, a quart of mixed spices was sprinkled throughout. One quart of 10 per cent vinegar was added to each barrel and the barrel was then completely filled with a brine solution testing eight per cent sodium chloride and headed. The contents of each barrel of dills consisted of the following:

240 to 250 pounds of fresh cucumbers
17 to 18 gallons of eight per cent salt solution
eight to twelve pounds salt cured dill weed
one pound mixed whole spices
one quart of ten per cent vinegar

The pickles were allowed to ferment for a period of six weeks. Analyses were made form the different barrels representing each type of soil at three different periods, at the beginning, on the fresh cucumbers, and at the end of three and six weeks during the fermentation of the pickles.

The results of the chemical and biochemical analysis at the different periods and for each type of soil are found in Table 1 for the year 1939, and Table 2 for the year 1940.

The moisture content of the fresh cucumbers (Tables 1 and 2) grown on the three types of soils varied only slightly for each type of soil. However, the variation in the moisture content of the fresh cucumbers grown in

1940 showed approximately a one per cent increase over 1939. The moisture content of the genuine dill pickles made from the fresh cucumbers grown on different types of soil varied but slightly irrespective of the year in which the cucumbers were grown. The total solids of the fresh cucumbers varied inversely with their respective moisture content. There was an increase of the total solids in the dill pickles resulting from pickling which was due to the absorbtion of salt and other added materials.

The ash varied directly with the amount of total solids and also with the amount of inorganic matter in the cucumber. There was a noticeable increase in the amount of ash in 1940 for the fresh cucumbers while in the pickles the variations are not as great. Cucumbers grown on muck loam in 1939 and 1940 showed an increase in both total solids and ash as compared with those grown on the other types of soil.

The protein in the cucumber usually varied with the amount of total solids. In 1939, the total solids in the cucumbers were greater than in 1940. The type of soil appeared to have but slight influence on the amount of protein in the fresh cucumbers as shown in Table 1. There is a greater variation in the protein content of the fresh cucumber grown in 1940 on the different types of soil as shown in Table 2. There is a decrease in the protein content of the dill pickles as compared with the cucumbers from which they were made due to the action of the brine

in which they were pickled and the subsequent fermentation which takes place. The brine and products of fermentation dissolved and soluble proteins which diffused into the brine and served as food for the micro-organism present. The greatest variation in the protein content of the cucumbers and the dill pickles occured in the cucumbers grown on muck. This would indicate either that there was more soluble protein in the cucumbers grown on muck or that the porosity of the cucumbers was greater which permitted more of the protein to diffuse out.

The simple carbohydrate in the fresh cucumbers was slightly higher in 1939 than 1940. This is to be expected since the total solids and the other constituents making up the total solids are likewise higher for 1939 than for 1940. The sugar had completely diffused out of the genuine dill pickles within four days. This confirms the work of Fabian and Wickerham who found in their work on dill pickles that all the sugar had disappeared from the dill pickle brine within six to eight days.

The amount of crude fat or ether extract increased in 1940 over that of 1939 in both the cucumbers and dill pickles. Tables 1 and 2 show that cucumbers grown on sandy loam had slightly more crude fat than those grown on the other types of soil. The crude fat of the pickles made in 1939 and 1940 showed an increase over the cucumbers from which they were made. There is a slight increase in the crude fat of the cucumbers grown in 1940

as compared to 1939.

The amount of calcium found in the cucumbers and the dill pickles made from them was fairly constant. The type of soil, the year in which the cucumbers were grown or fermentation had but slight influence upon the amount present. This would indicate that it is in a stable form presumably constituting a part of the cell wall structure of cucumbers.

Phosphorous was likewise fairly constant in amount in the cucumbers grown in the two different years. In all cases except one there was a slight drop in the phosphorus content of the dill pickles as compared to the amount found in the cucumbers from which they were made.

Iron is considered a trace element in plants. The content of iron in 1939 varied slighly. The cucumbers grown on sandy loam had a trace more of iron than those grown on muck or clay soils. The results secured in 1939 checked exceptionally well with those obtained in 1940. The amount of iron found in the dill pickle was slightly less in all cases exdept one than the amount in the cucumbers.

The copper content of cucumbers in the three types of soil in year 1939 showed some variation. The amount of copper in cucumbers grown in sandy loam contained the most copper. Next in amount were those grown on clay and least in amount were those grown on muck. The copper

content of the genuine dill pickles made from the cucumbers grown on the different types of soil showed an increase as compared to the cucumbers. This increase may be due to two factors: It may have come from the one quart of 100 grain vinegar added to each barrel of dills or it may have been due to the higher total solids content of the pickles as compared with the fresh cucumbers. Vinegar frequently contains a trace of copper, and the copper content of the vinegar used was not determined. If the copper was combined with the plant cell in an insoluble form, as is most likely, it would not be dissolved out of the cucumbers when they were fermented and would be present in the pickles as a part of the total solids in a greater ratio than in the cucumbers.

The carotene content of fresh cucumbers grown in 1939 in the three types of soil varied little in amount. Table 1 shows that cucumbers grown on clay contained the largest amount of provitamin A, next in order were the cucumbers grown on muck, and then sandy loam cucumbers. The genuine dill pickles (1939) showed a large increase in carotene after four days of fermentation and continued to increase until the sixth week after which there was a slight decrease. In 1940, Table 2, the carotene content of fresh cucumbers which were grown on three different types of soil showed only a slight variation from cucumbers grown on muck and clay while those grown on the sandy loam soil did not contain as much. The genuine dill pickles (1940) likewise

showed an increase in carotene content during fermentation. On the whole, the provitamin A content of both the cucumbers and dill pickles for the two year series compared exceptionally well. Attention should also be called to the fact that a different method was used the second year.

The amount of vitamin B_1 in fresh cucumbers grown in 1939 showed no difference between the sand and clay loam cucumbers. The muck cucumbers contained much. It was not possible to determine the amount of vitamin B_1 in genuine pickles for the year of 1939 due to the fact that the rats would not eat the pickles. There was no difference in the vitamin B_1 content of fresh cucumbers grown in 1940 on three different types of soil. During fermentation there was a decrease in the vitamin B_1 content. It must be taken into consideration that a large amount of cucumber or pickle material must be fed which limits the amount of basal food ingested and thereby limits the amount of growth. In addition, the fact that vitamin B_1 is unstable could account for the low values obtained.

The vitamin B_2 content was the same for fresh cucumbers grown on the three different types of soil in 1939. The subsequent pickling and fermentation caused a decrease in the amount of vitamin B_2 but the decrease was the same in all cases for all types of soil. Since vitamin B_2 is water soluble doubtless some of it is dissolved, and was removed during the manufacture of the dill pickles. In 1940, the vitamin B_1 content on fresh cucumber grown on

different types of soil showed only slight variations. Cucumbers grown clay being the highest and sandy loam the lowest. The amount of vitamin B_2 was less in 1940 than in 1939, in both the cucumbers and the dill pickles made from them. Likewise in 1940, the manufacturing process affected the vitamin B_2 content to a greater extent than in 1939. Vitamin B_2 is a more stable compound than vitamin B_1, so that the factors most likely responsible for the decrease are water solubility and the salting out of the vitamin.

The amount of vitamin C in fresh cucumbers grown on different types of soil in 1939 and 1940 checked very closely. The values obtained were higher than those reported by Heinz (30). The manufacturing process caused a loss of approximately 40 to 60 per cent of the vitamin C content. There was a gradual loss as the fermentation continued, the loss being comparable to that found in the conversion of cabbage into sauerkraut. Pederson, Mack and Athawes (27) found a loss of from one-third to one-half the vitamin C content of kraut during canning and also in holding it in the vat after the fermentation is completed. During prolonged storage this loss may be even greater. The loss of vitamin C is greater if fermented and stored in small containers. Heinz (30) found cabbage to contain 1000 International units per 100 grams while sauerkraut contained from 0 to 190.

There was no vitamin D present in either the cucumbers

or pickles as judged by the method used.

Influence of Manufacturing Process

Salt stock pickles. The first step in the manufacture of certain types of pickles, such as sweet, sour, mustard, and processed dill pickles, is the salting of the fresh cucumbers. It is necessary to salt and hold them for varying lengths of time (three months to three years or more) since the cucumber harvest season is of such short duration, approximately four to eight weeks.

The salting procedure for cucumbers used in making the salt stock for the sweet and processed dill pickles for these experiments was as follows: The fresh cucumbers were placed in a 600 bushel tank, and while the tank was being filled, a 7.85 per cent (30 degree salometer) brine solution of sodium chloride was added in a sufficient amount to completely cover the cucumbers. When the vat was filled, a false cover was placed over them and fastened in such a manner so as to completely submerge the cucumbers. They were permitted to ferment and cure for a period of about three months. During the curing process salt was added at weekly intervals so that at the end of this period the brine tested 11.2 per cent by weight. The resulting product is known as "salt stock". The influence of the salting of fresh cucumbers on their nutritive value is shown in Table 3.

Sweet pickles are made from salt stock. The method used for the experiments reported here briefly was as follows: Salt stock was soaked in water for twelve hours. This water was discarded and fresh water added to the pickles. The temperature of the water and pickles was raised to 130 degrees F. and the pickles allowed to remain in this water for one hour. The water tested 3.4 per cent salt (13 degree salometer)at this time. The withdrawal of salt from the pickles is called "freshening" and the freshened pickles after heating are called "processed stock". The processed stock was made into sweet pickles by the addition of 13 per cent distilled vinegar, and sufficient sugar to make the final test of the pickles and liquor come to 34.5 Brix (19 degrees Baume). A combination of spices oils was also added. These ingredients were placed over the processed pickles and allowed to stand ten days. At the end of this time the pickles were sweet and tested two per cent acetic acid (20 grains), 29.3 per cent sugar and two per cent salt and contained one part of spice oils to 4600 parts of material. The analysis of sweet pickles if given in Table 3.

Processed dill pickles are also made from salt stock. The salt stock was freshened and processed the same as for sweet pickles. In these experiments enough salt stock was freshened to make both the processed dill and the sweet pickles. To the processed stock was added a brine consisting of vinegar, salt and dill spice oil. They were

allowed to stand in this brine two days after which the pickles tested 0.67 per cent acetic acid, 3.9 per cent salt (17 degrees salometer).

The analysis of the fresh cucumbers and the influence of salting, processing and finishing them into an edible product are given in Table 3.

Influence of Salting

Salting the fresh cucumbers according to the procedure outlined reduced the moisture content, increased the amount of total solids and ash (Table 3). The salting process also reduced the protein content and caused a complete disappearance of the sugars. The crude fat in the salt stock pickles was increased by one-tenth of a per cent. This increase can be accounted for by taking into consideration the increased total solids which gave a greater concentration of the material to be extracted. There was a slight increase in the calcium content which may be due to the greater amount of ash in the salt stock than in the fresh cucumber. The phosphorus decreased after salting and iron varied only a small amount. The copper content of cucumbers after salting increased about 615 per cent.

The carotene content of the salt stock increased approximately three times as compared with the fresh cucumbers. This is doubtless due to the insolubility of vitamin A in the brine and the greater concentration of the total solids. The vitamin B_1 content was decreased by the salting process

indicating that since it was water soluble, it was removed with the water during diffusion of the water out of the cucumbers during salting. It is also unstable and may have decomposed. What has been said regarding vitamin B_1, also holds true for vitamin B_2, which showed a decrease. The vitamin C content showed a considerable decrease after the salting process. This decrease may be attributed to diffusion, because vitamin C is water soluble, as well as to its destruction.

The moisture content of the sweet pickles showed a great decrease due mostly to the addition of sugar during their manufacture, while the moisture content of processed dill pickles increased slightly. In the case of the sweet pickles, the sugar replaced the moisture, where as with the processed dill pickles, the addition of salt and acid to the processed stock caused more water to go into the pickle. The total solids increased accordingly in the case of the sweet pickles where as the total solids in processed dills decreased approximately 3.3 per cent due to the increase in moisture content which in this case was 3.5 per cent. There was a 67 per cent decrease in the ash of the sweet pickle as compared with the salt stock but a 300 per cent increase over that of the fresh cucumber. The decrease is due to the withdrawal of salt from the salt stock and the increase is due, in part at least, to the addition of sugar to the processed stock. The amount of ash in the processed dill pickles was less because most of the salt was removed

from the salt stock during the manufacture of processed dill pickles.

The protein content in sweet pickles took approximately a three per cent drop where as the protein content in the processed dill pickles fell approximately 0.5 per cent. This decrease may be explained on the basis of the lowering of the total solids as compared with the salt stock. The amount of sugar present in the sweet pickles was the amount added during their manufacture. The crude fat in sweet pickles decreased in comparison with that found in the salt stock, due to the increased total solids of the sweet pickles. There was likewise a slight decrease in the crude fat of processed dill pickles. This slight loss is again due to the loss in total solids as compared with the salt stock pickles. The calcium content in both the sweet pickles and processed dills diminished with respect to the amount of ash as compared with the initial salt stock. The same was true in the case of phosphorus, but the phosphorus content in the sweet pickle was greater than that of the processed dill pickles. The iron content of sweet pickles and processed dills was less than in salt stock or the fresh cucumbers. The difference in copper content was very slight.

There was a loss of provitamin A in both sweet and processed dill pickles as compared to the salt stock. The loss was greater in the former than in the latter. Vitamin B_1 had practically disappeared during the salting of the

cucumbers and it completely disappeared during the processing and finishing of the sweet and processed dill pickles. There was no loss of vitamin B_2 during the processing and finishing of the sweet and processed dill pickles indicating that the manufacturing processes had less influence on it. It also indicates the stability of this vitamin. The vitamin C content in the sweet and processed dill pickles was nearly the same as in the salt stock pickles. This indicates that the residual vitamin C is in a fairly stable form.

Nutritional Studies on Fresh Cucumber Pickles

Fresh cucumber pickles are made from fresh cucumbers by the addition of acid, with or without sugar, salt and spices. They differ from genuine dill pickles in that they are not fermented and from sweet, sour, mustard, and processed dill pickles in that they are neither fermented or processed. Two different types of fresh cucumber pickles were made and studied in this work. Pasteurized dill pickles were made by washing fresh cucumbers and placing them in quart glass jars containing two sprigs of dill weed, one tablespoon full of whole mixed spices and then filling the jar with a brine consisting of vinegar, water, and spice oils. It was found that the pickles were of such a size to occupy 60 per cent of the volume of the jar and the rest of the space was filled with brine. The filled jars were then pasteurized at a tempera-

ture of 160 to 165 degrees F. for 30 minutes and cooled immediately. After equilibrium had been established the acetic acid content was 0.4 per cent and the salt 2.25 per cent.

Bread and Butter pickles were made by slicing washed fresh cucumbers to a thickness of from five to seven millimeters and adding one pound of sliced onions for each 200 pounds of sliced cucumbers. These were then placed in a 6.6 per cent (25 degrees salometer) salt brine. For each 16 gallons of brined sliced cucumbers and onions, 5.5 ounces of turmeric were added. They were allowed to remain in this solution from four to twelve hours after which they were dipped out and placed in ten ounce jars. The jars were then filled with 2.25 ounces of a syrup consisting of 4.3 per cant acetic acid, 50 per cent sugar and one part tumeric to 350 parts of the syrup. The jars were then vacuum sealed and pasteurized at 170 degrees F. for 25 minutes.

The analysis of the fresh cucumbers, the pasteurized dill pickles and the bread and butter pickles are given in Table 4.

A Study of Pasteurized Dill Pickles

A comparison of pasteurized dill pickles with the fresh cucumbers from which they were made shows that during the manufacturing process the moisture content decreased and the total solids increased by two per cent.

There was a slight drop in the protein and a considerable reduction in the sugar content of the pickles. However, the reduction is not as great as in the salt stock where it all disappears. There was a slight increase in crude fat.

The mineral constituents such as calcium and phosphorus are affected but slightly by manufacture whereas iron and copper show increases which may be due to traces of these minerals in the salt and vinegar.

There was not as much change in the vitamin content of the pasteurized dill pickles as in the salt stock. As usual there was an increase in the carotene content in the manufactured pickle over that found in the fresh cucumber. The vitamin B_1 decreased but slightly. There was about a 40 per cent decrease in vitamin B_2 and a 20 per cent decrease in vitamin C. In general the vitamin destruction was far less in this type of pickle than in the salt stock pickles. The detailed results are found in Table 4.

A Study of Bread and Butter Pickles

There was a considerable change in the moisture, total solids, ash, protein and simple carbohydrate content of the bread and butter pickles as compared with the fresh cucumbers from which they were made. These changes are due to the materials added to the cucumbers during their manufacture as well as the several processes through which they passed during manufacture. The reduced moisture, the increased

total solids, ash, and simple carbohydrates is due to the addition of sugar, salt, acid and turmeric.

There was an increase in all the minerals of approximately 50 per cent in the bread and butter pickles as compared with the fresh cucumbers from which they were made. The increase is due to the increase in the ash content of the pickles over that of the cucumbers because of the addition of substances such as sugar, salt and vinegar.

The vitamin content of the bread and butter pickles compared very favorably with the vitamin content of the fresh cucumbers from which they were made. There was much less change due to the manufacturing process than in the case of salt stock. This indicates that the procedure used to convert the fresh cucumbers into bread and butter pickles was less destructive to vitamins than other types of treatment such as salting. There was approximately 125 per cent increase in vitamin A, no loss of vitamin B_1, a decrease of about 30 per cent in vitamin B_2 and about a 20 per cent decrease in vitamin C. These decreases are considerably less than was the case for salt stock. The results are found in Table 4.

General Discussion

The moisture content was affected most by the manufacturing process of the bread and butter and the sweet pickles. These losses indicated the addition of more soluble material, consequently increasing their

total solids respectively. The ash content was most abundant in salt stock because of the large amount of salt that was added. As far as the cucumbers were concerned there was not very much difference in the amount of ash. However the amount of ash in the various types of pickles varied with the quantity of salt added. The protein in cucumbers was diminished in the preparation of these various types of pickles. The processed dill pickles showed the least amount of protein. Simple carbohydrates were present only in the case of sweet, bread and butter, and pasteurized dill pickles. This was due in the first two types to the addition of sugar.

The crude fat decreased in the making of the bread and butter and the sweet pickles whereas in the other various pickles the crude fat increased. In most cases the quantity of crude fat varied directly with the amount of total solids, but in the case of the sweet and bread and butter pickles the crude fat decreased with the increased total solids. The calcium content was diminished by the processing and finishing of pickles as in the sweet and the processed dill pickles. The phosphorus content of the cucumbers was reduced in the various manufacturing processes with the exception of one type, the cucumbers grown on clay loam in 1940. The manufacturing process affecting the phosphorus content most was that used in the case of processed dill pickles. The iron content of cucumbers made into pasteurized dill and bread and butter pickles increased. This increase may have been due to added ingredients. The iron content in all the other cases

decreased except in pickles made from cucumbers grown on muck in 1939. The copper content of the cucumbers made into the various pickles showed a definite increase. This increase may have been due to some added ingredients such as vinegar, spices and etc.

The amount of carotene in the various cucumbers was increased during these various pickling processes. The affect of processing and finishing (sweet and processed dill pickles) showed a small decrease on vitamin A content. The salt stock contained more carotene than the other types.

The processing of pasteurized dill and bread and butter pickles had practically no affect on vitamin B_1. There was less loss of vitamin B_2 due to the processing and finishing of sweet and processed dill pickles than there was in the other types of manufactured pickles. The greatest loss occured in the making of salt stock. In the fermented type of pickles, such as dill pickles, the loss ranged from one-third to one half of that found in the fresh cucumber.

The greatest loss of vitamin C occurredwhen fresh cucumbers were converted into salt stock pickles by the addition of approximately eleven per cent sodium chloride. The vitamin C content was least affected in the making of the pasteurized dill and the bread and butter pickles. The vitamin C in the genuine dill pickles diminished as fermentation progressed. The processing and finishing of the salt stock into sweet and processed dill pickles had very little affect on the vitamin C content.

Summary

1. There was an increase in the total solids and a decrease in the moisture content in practically all the various kinds of pickles as compared with the fresh cucumbers from which they were made. In the case of sweet and bread and butter pickles these changes were especially pronounced due to the materials added during their manufacture.
2. There was a definite decrease in the protein content of the various types of pickles as compared with the fresh cucumbers from which they were made.
3. The simple carbohydrates were removed during the first four days of fermentation in the two kinds of fermented pickles studied- genuine dill and salt stock pickles.
4. In most cases the quantity of crude fat varied directly with the amount of total solids.
5. There was a reduction in the calcium and phosphorus content of pickles as compared with the fresh cucumbers from which they were made. The reduction was greatest for processed dill pickles.
6. In most instances there was a slight loss of iron in the pickles due to the manufacturing processes. However, there was an increase in the iron content in the case of pasteurized dill and bread and butter pickles.
7. In general there was an increase in the copper content of the pickles over that found in the fresh cucumbers from which they were made.
8. The carotene content in the different lots of fresh

cucumbers increased during their manufacture into pickles. The increases ranged from 23 per cent for pasteurized dill pickles to 261 per cent for salt stock pickles.

9. There was a diminution of all other vitamins studied when the fresh cucumbers were made into genuine dill pickles. In the six weeks period there was a loss of approximately 50 per cent of B_1, B_2, and C.

10. The process producing the greatest loss of vitamins, with the exception of carotene, was salting. The processing and finishing of the salt stock into sweet and processed dill pickles changed the vitamin content but little.

11. There were vitamin losses, except in the case of carotene, from approximately 12.5 to 40 per cent when fresh cucumbers were made into pasteurized dill and bread and butter pickles. However, the losses due to the conversion of fresh cucumbers into these types of pickles were less than for salt stock which ranged from 75 to 85.7 per cent and for genuine dill pickles which ranged from 33.3 to 87.5 per cent.

Conclusions

1. The greatest changes in composition of the fresh cucumbers occured when they were made into salt stock pickles, and the least when they were made into pasteurized dills or bread and butter pickles.

2. There was a substantial increase in carotene content of the pickles as compared to the fresh cucumbers from which they were made.

3. The loss of vitamin B_1 was the greatest, followed by B_2

and C when fresh cucumbers were converted into pickles.

Table 1. Analysis of cucumbers grown in 1939 on sand, muck, and clay soil and of genuine dill pickles made from them.

	Fresh cucumbers			Genuine dill pickles					
Per cent*	Sand	Muck	Clay	Date 1939	Sand	Per cent change	Muck	Per cent change	Clay	Per cent change
Moisture	93.99	93.59	94.34	10/6	92.593	- 1.5	94.643	1.1	92.609	- 01.8
Total solids	6.01	6.41	05.65	10/6	7.381	22.8	5.357	- 16.4	7.342	030.0
Ash	0.659	0.726	00.490	10/6	4.732	618.1	3.213	342.6	4.347	787.1
Protein	1.001	1.010	1.162	9/15	0.665	- 33.6	0.709	-29.8	0.707	- 39.2
				10/6	0.615	- 38.6	0.555	- 45.0	0.664	-042.9
Simple carbohydrate	1.772	2.214	1.612	8/29	0.0	-100.0	0.0	-100.0	0.0	-100.0
Fat	0.1370	0.117	0.128	10/6	0.218	59.1	0.190	62.3	0.225	75.8
Calcium	0.0226	0.0276	0.0168	10/6	0/0280	23.9	0.030	8.7	0.0290	+ 72.6
Phosphorus	00.0235	0.0268	0.0249	10/6	0.0175	- 25.50	0.021	- 22.4	0.0177	- 28.9
Iron (mgm/kgm)	13.9	8.4	11.10	10/6	9.5	- 31.6	11.1	32.1	6.7	- 39.6
Copper (mgm/kgm)	5.0	3.0	3.75	10/6	6.71	34.2	8.84	188.0	5.0	33.3
Vitamin A	260.0	270.0	290.0	8/29	490.0	88.4	360.0	33.3	510.0	75.8
				9/15	520.0	100.0	340.0	25.9	520.0	79.3
				10/6	490.0	88.4	400.0	48.1	460.0	58.6
Vitamin B	10.0	20.0	10.0	10/6	**		**		**	
Vitamin B_2	90.0	90.0	90.0	10/6	060.0	- 33.3	60.0	- 33.3	60.0	- 33.3
Vitamin C	243.0	234.0	235.0	10/6	132.0	- 45.6	135.0	- 42.3	135.0	- 42.5
Vitamin D	0.0	0.0	0.0	10/6	0.0		0.0		0.0	

*Per cent unless otherwise noted. **Rats would not eat pickles
Vitamins expressed in International units per 100 grams except vitamin B_2 which is in Sherman-Bourquin units per 100 grams.

Table 2. Analysis of cucumbers grown in 1940 on sand, muck, and clay soil, and of genuine dill pickles made from them.

	Fresh cucumbers 9-6-40			Genuine dill pickles						
Per cent*	Sand	Muck	Clay	Date 1940	Sand	Per cent change	Muck	Per cent change	Clay	Per cent change
Moisture	95.381	94.926	95.011	10/18	92.357	- 31.7	93.194	-18.2	92.837	- 22.9
Total solids	4.618	5.074	4.989	10/18	7.643	65.5	6.806	34.1	7.163	43.6
Ash	0.274	0.438	0.381	10/18	4.156	1416.8	3.861	781.5	3.742	882.1
Protein	0.848	1.060	0.731	9/27	0.805	- 5.0	0.7260	-31.5	0.727	- 0.5
				10/18	0.794	6.4	0.689	-35.0	0.721	- 0.5
Simple carbohydrate	1.63	1.59	1.58	9/10	0.0	-100.0	0.0	-100.0	0.0	-100.0
Crude fat	0.158	0.156	0.137	10/18	0.218	38.0	0.215	37.8	0.200	46.0
Calcium	0.0175	0.0275	0.030	10/18	0.0265	51.4	0.0259	5.8	0.0198	- 34.0
Phosphorus	0.0262	0.0300	0.026	10/18	0.0237	9.5	0.0212	- 29.3	0.0286	10.0
Iron (mgm/kgm)	13.9	13.90	12.0	10/18	8.7	37.4	6.7	- 51.8	5.5	- 54.2
Copper (mgm/kgm)	1.8	2.8	2.7	10/18	6.2	24.4	8.5	203.5	6.4	137.0
Vitamin A	216.0	266.0	250.0	9/27	350.0	62.0	350.0	31.5	358.0	43.2
				10/18	335.0	55.0	442.0	66.1	412.0	64.8
Vitamin B_1	8.0	8.0	8.0	10/18	1.0	- 87.5	2.0	- 75.0	1.0	- 87.5
Vitamin B_2	25.0	30.0	35.0	10/18	12.0	- 52.0	15.0	- 50.0	15.0	- 57.1
Vitamin C	250.0	287.0	266.0	9/27	155.3	- 37.8	127.0	- 55.7	132.0	- 50.3
				10/18	155.0	- 38.0	110.0	- 61.6	105.0	- 60.5
Vitamin D	0.0	0.0	0.0	10/18	0.0		0.0		0.0	

* Per cent unless otherwise noted.
Vitamins expressed in International units per 100 grams except vitamin B_2 which is in Sherman-Bourquin units per 100 grams.

Table 3. Analysis of fresh cucumbers, salt stock, processed and finished pickles showing the influence of the various manufacturing operations on the composition.

Per cent*	Fresh cucumbers	Salt Sto. pickles	Percent change	Sweet pickles	Percent change	Processed dills	Percent change
Moisture	95.00	90.167	- 5.1	63.810	- 32.8	93.357	- 1.7
Total solids	5.005	9.839	96.5	36.190	623.00	6.643	32.7
Ash	0.519	6.481	1148.7	2.038	292.7	3.833	638.5
Protein	1.427	1.038	- 27.3	0.701	50.9	0.5335	62.6
Simple carbohydrate	1.16	0.0	-100.0	29.3	2425.8	0.0	-100.0
Crude fat	0.058	0.152	162.1	0.0380	-34.4	0.128	120.6
Calcium	0.0315	0.0336	6.7	0.0114	-63.8	0.0138	- 53.0
Phosphorus	0.0379	0.0288	- 24.0	0.0233	-38.5	0.0151	- 60.2
Iron (mgm/kgm)	12.0	11.6	- 3.3	3.0	-75.0	3.60	- 70.0
Copper (mgm/kgm	1.8	8.4	36.6	6.5	261.1	8.3	361.1
Vitamin A	166.0	600.0	261.4	409.0	146.38	492.0	196.38
Vitamin B_1	7.0	1.0	- 85.7	0.0	-100.0	0.0	-100.0
Vitamin B_2	40.0	10.0	- 75.0	10.0	0.0	12.0	20.0
Vitamin C	293.0	44.8	- 84.7	44.8	0.0	40.0	- 10.7
Vitamin D	0.0	0.0		0.0		0.0	

* Per cent unless otherwise noted.

Vitamins expressed in International units per 100 grams except Vitamin B_2 which is in Sherman-Bourquin units per 100 grams.

Table 4. Analysis of Fresh cucumbers, pasteurized dill pickles, and bread and butter pickles made from them.

Percent*	Fresh cucumbers	Pasteurized dills	Percent change	Bread and Butter	Percent change
Moisture	95.177	93.756	- 1.5	79.531	16.4
Total Solids	4.823	6.243	29.4	20.469	324.4
Ash	0.543	2.342	331.3	2.372	336.8
Protein	1.067	0.744	- 30.3	1.029	- 3.6
Simple carbohydrate	1.46	0.86	- 41.1	15.3	947.9
Crude fat	0.102	0.110	7.8	0.099	- 2.9
Calcium	0.0208	0.0225	8.2	0.0300	44.2
Phosphorus	0.0275	0.0223	- 18.9	0.0301	9.4
Iron (mgm/kgm)	11.30	18.00	59.3	20.6	82.3
Copper (mgm/kgm)	2.20	2.5	13.6	3.8	72.7
Vitamin A	200.0	292.0	48.0	458.0	129.0
Vitamin B_1	8.0	7.0	- 12.5	8.0	0.0
Vitamin B_2	25.0	15.0	- 40.0	17.0	- 32.0
Vitamin C	255.0	180.0	- 29.4	200.0	- 21.5
Vitamin D	0.0	0.0		0.0	

*Percent unless otherwise noted.
Vitamins expressed in International units per 100 grams except Vitamin B_2 which is in Sherman-Bourquin units per 100 grams.

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