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The Vitamin C Content of Fresh and Canned Spinach, Swiss Chard, Asparagus and Carrots

G.E. Wasson

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The Vitamin C Content of Fresh and Canned Spinach, Swiss Chard, Asparagus and Carrots

Department of
Home Economics
AGRICULTURAL EXPERIMENT STATION
South Dakota State College of
Agriculture and Mechanic Arts
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A Study of
**The Vitamin C Content of Fresh and Canned Spinach
Swiss Chard, Asparagus, and Carrots**

By
Grace E. Wasson

The object of this study has been to determine the Vitamin C content of certain canned vegetables, and to determine to what extent the Vitamin C content of the fresh products is reduced by the canning process. The vegetables used have been spinach, Swiss chard, asparagus and carrots.

In this preliminary study there are several discrepancies. Probably the most outstanding weakness comes in the diagnosis, especially during the early part of the experiment when too much consideration was given to growth curves and general conditions, and conclusions were often drawn without microscopic examination of the bones. Also, there are some indications that the basal ration was not absolutely Vitamin C free (1), as the negative controls lived longer and did not show the big decrease in weight recorded by Sherman (8), Hess(3) and other investigators.

Method of Procedure

In accordance with the established procedure the tests were run on young guinea pigs. Sherman, La Mer, and Campbell's (8) basal ration was used with one modification; equal portions of bran and rolled oats were substituted for the ground oats.

Rolled oats and bran	59%
Milk powder heated in shallow tray at 110° for about two hours	30%
Clarified butterfat	10%
Sodium Chloride	1%

This ration was fed ad libitum throughout the 90 day test period, as well as prior to starting the experiment.

Circumstances have been such that it was necessary that the guinea pigs which have been used in experimental work be purchased when young, rather than raised at the college. They have been obtained through two different distributing companies of Kansas City, Missouri. As a rule, this arrangement has been satisfactory, but sometimes they have been shipped during very cold and stormy weather, and such conditions are hazardous in the case of such young animals. Once or twice there has been serious respiratory affections and a good many pneumonia cases. Occasionally other infections have developed to an annoying extent, and twice vermin have infested shipments. There is also the possibility that their early diet may have been deficient. On the other hand, in buying the young guinea pigs it is possible to have a desired number of approximately the right size and age for an experiment, when it would not be possible if the animals were to be supplied from college breeding pen, unless the institution was fortunate enough to own considerable breeding stock.

When a shipment is received, the pigs are held from two to four weeks before starting the experiment. In this preliminary period, the pigs are fed basal ration and a generous supply of green vegetables, as well as

some of the product to be tested. They are weighed two or three times a week. The size, physical condition, rate of gain and any peculiarity of food habits are noted. All animals unfit for experimental purposes are culled.

The cages are sterilized in the auto clave before a new lot of pigs is put in them. The trays are removed and refilled with fresh sawdust each morning, except Sunday. Once a week the trays are scalded, the cages removed from the racks and the shelves cleaned. It may appear that an unnecessary amount of time must be consumed in cleaning, but as the animal room is located in the administration building, it is imperative to eliminate all traces of objectionable odors. By this care, good ventilation, and by finally securing a drinking cup that cannot be overturned, thus keeping the trays and sawdust dry, the room is practically odorless. Fresh basal and water are given each morning in clean dishes.

Each pig has a separate cage, which is marked with the best quality of cloth shipping tag, fastened to the cage by means of tie-wire. On this tag is the pig's number, the amount of protective food it receives daily, date of starting the feeding and an accurate description of the pig.

In making the final grouping for the experiment, the size, the average daily gain, regularity of gain during the preliminary period, general condition and food habits of the individual pigs are taken into consideration in order to make the groups comparable. In different tests, the number of pigs in a group have varied from five to ten.

The pigs are weighed three times a week during the test period and the weight recorded.

The product being tested is weighed out each morning according to the daily dosage. In the case of canned vegetables, glass castor cups have been found most satisfactory for feeding dishes. They are heavy enough and of such a shape that it is almost impossible for a guinea pig to overturn them. In every lot of pigs there are usually a few that seem to delight in wasting their food.

As a rule the pigs are given their protective dosage each morning, before they are given basal and water, especially if they are at all slow about eating the vegetables. If one tends to waste his daily portion, or is slow about eating it, notation to that effect is made in the record book. Notation is, also, made of any unusual development as dull eyes, rough coat or any change that might be an early manifestation of scurvy.

The pigs that die before the close of the experiment are autopsied and the ribs are saved for microscopic examination.

At the end of the ninety day period, all the pigs are anesthetized and autopsied. The apparent state of nutrition is noted. In post-mortem the following points are considered:

1. Amount of fat, both mesentery and subcutaneous.
2. The color and condition of the muscle tissues.
3. Hemorrhages in muscle and subcutaneous tissues, peritoneum and abdominal organs.
4. Enlargement of joints and costochondrals.
5. Condition of bones, brittleness, etc.
6. Condition of the teeth.
7. Heart and lungs.
8. Alimentary tract.

9. The ribs and wrist joints are saved for microscopic examination.

The histological determinations have been made by Dr. J. B. Taylor, professor of veterinary science, South Dakota State College.

Experimental Scurvy

In 1895 Theobald Smith (14) noted that guinea pigs died in from four to eight weeks when fed on oats and bran and deprived of green vegetables. He described the hemorrhages and other conditions now recognized as characteristic of scurvy.

In 1907 Holst and Froelich (5) started a systematic study of "ship beriberi," and concluded that it was an nutritional rather than an infectious disorder. Some five years later they pointed out that the syndrome produced in guinea pigs fed on a strict cereal diet was analogous to scurvy in man.

Rats and fowls are immune to scurvy. Scurvy can be produced in monkeys and rabbits. Guinea pigs are of a convenient size, are cleanly, prolific, and mature rapidly, hence are desirable for laboratory use.

The pathology of scurvy in human beings and guinea pigs is quite alike, except that hemorrhages rarely occur in the gums of guinea pigs while they frequently do in human beings. (3)

One of the basic peculiarities of scurvy is the lack of power manifest by tissues to produce and maintain the intercellular substances which give normal character to the structure. Because of this inability the walls of the capillaries and small blood vessels are weakened, and hemorrhages result. The inability to form the bone matrix results in the fragility and the abnormalities of bones and teeth.

With guinea pigs, the lack of Vitamin C is early manifest by the changes that take place in the teeth. Occasionally the incisors become loose, and drop out; more often they become dull, or of a yellowish color in place of being glistening white. Frequently they break or chip off. Quite commonly the molars become loose. The histological changes in the teeth take place early and are marked. Recently cross sections of teeth have been used for histological determinations of scurvy. Eddy (23) reports the successful use of Hojer's method which involves microscopic study of the molars.

In comparing it with the much used Sherman's method of diagnosis, he suggests as its advantages that it is more specific and demands a much shorter feeding period. Dalldorf and Zall (16) propose to determine scurvy by the pathological study of the lower incisors and state that "Under standard experimental conditions used in the testing of food stuff for anti-scorbutic value, the rate of tooth growth would appear to be precise indication of the degree of scurvy, being more delicate than the Sherman score and more constant as well as more simple than the Hojer method."

The pioneers in the field of vitamin studies have done a laudable piece of work. They have laid a foundation for further investigation. Though many discoveries have been made and many facts established, there is much yet to be done. Today when so many institutions of higher learning are doing research along this line, one of the gravest needs is for greater uniformity in methods of conducting investigation, and definite standards for diagnosis in final determinations in order that results from different laboratories may be comparable.



PLATE I

Microphotograph of a normal rib at the costochondral junction. Note the characteristic orderly columnar arrangement of cartilage cells. (A)

Ten grams of commercially canned spinach.*

* Slides made of lengthwise sections of guinea pig ribs at the costochondral junction.

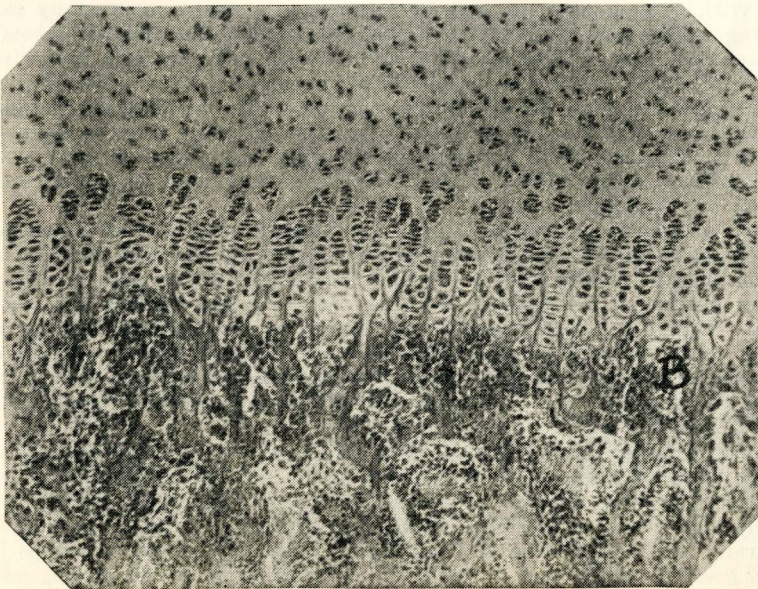


PLATE II

Microphotograph of a practically normal rib at the costochondral junction. Note the fairly regular trabeculae. (B)

Ten grams home grown, home canned spinach.

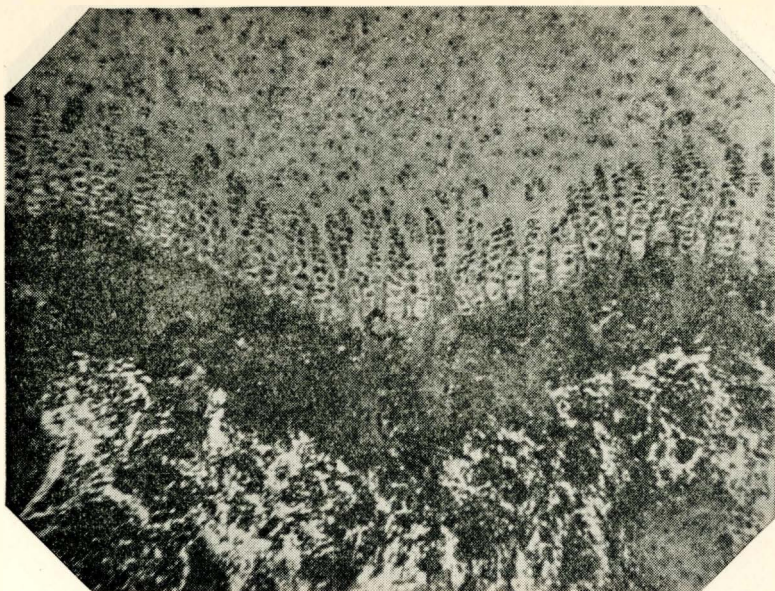


PLATE III

Microphotograph showing slight indication of scurvy, noted chiefly by the indentation of the line of preparatory calcification. (C) The rows of cartilage cells are about normal.

Ten grams home grown, home canned spinach.



PLATE IV

Microphotograph indicating scurvy noted chiefly by somewhat disorganized arrangement of cartilage cells and irregularity of trabeculae. (D)

Five grams home grown, home canned spinach.

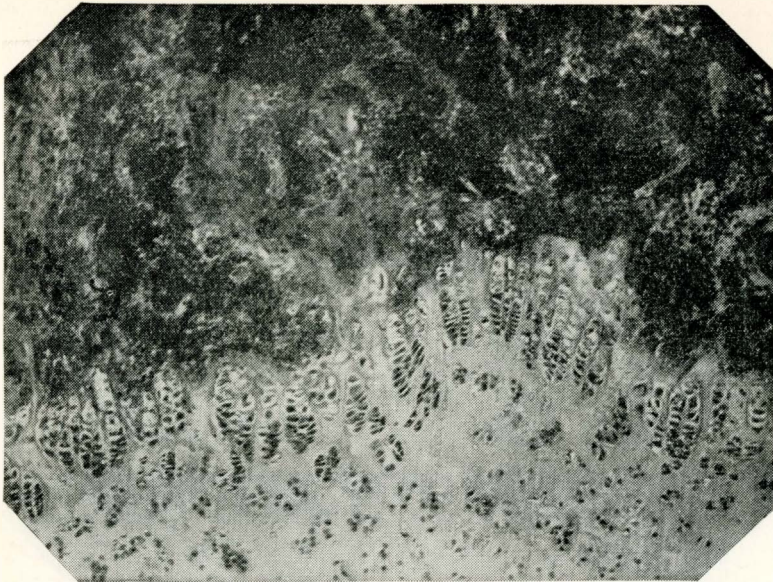


PLATE V

Microphotograph indicating scurvy as shown by indentation of line of preparatory calcification, and indefinite trabeculae. (E) A part of the cartilage cells are still fairly orderly in arrangement.

Five grams home grown, home canned spinach.

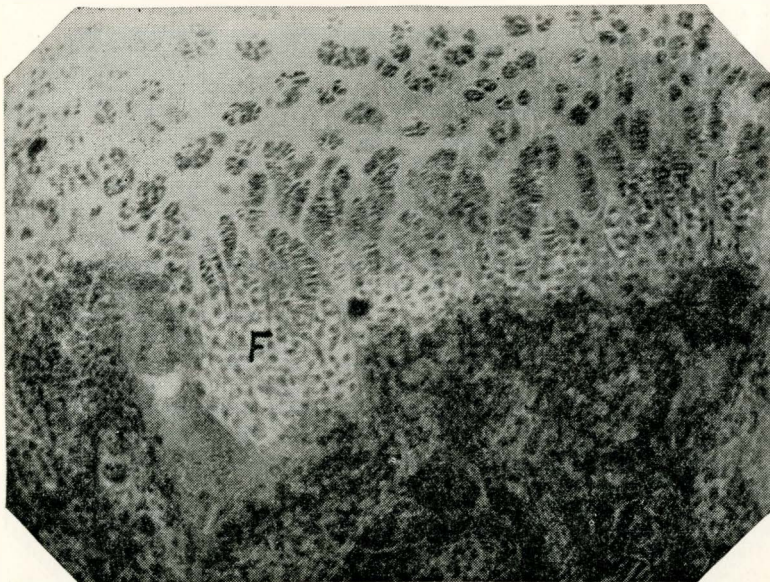


PLATE VI

Microphotograph showing a more advanced stage of scurvy as noted by the indentation of line of preparatory calcification, cartilages in masses, (F) and the disappearance of trabeculae.

Five grams home grown, home canned spinach.

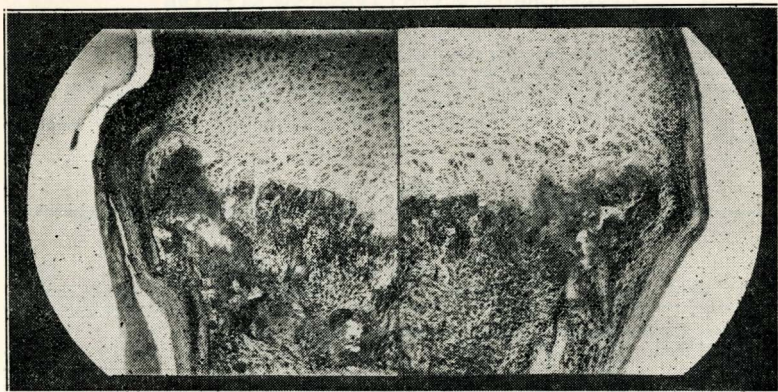


PLATE VII

Microphotograph of the costochondral junction in the rib of a scorbutic pig. (Two exposures were made of this same microscopic slide, in order to show outer edges.)

This illustrates the typical histologic changes in a costochondral junction. The cartilage cells are no longer in columnar rows, the line of preparatory calcification is irregular; the trabeculae, where distinguishable, are short and broad; there are hemorrhages in the marrow cavity and macroscopic deformity is in evidence.

Spinach and Swiss Chard

In the work with spinach the first series of tests was run on a good grade of commercially canned spinach and a home canned product.

The commercially canned spinach was purchased in case lots, No. 2 cans. A fresh can was opened each morning and the juice, of which there was but a small amount, was mixed with the solid portion for feeding and the daily dosage carefully weighed.

The spinach for the home canned product was purchased in bushel baskets from a grocery store during the month of May. It was grown outside of the state and was handled through the local dealer and a wholesale house. There was no means of checking on the length of time that elapsed between the picking and canning. In some baskets there was considerable waste and spoilage. The canning was done in the laboratory. The spinach was thoroughly washed, blanched two minutes and put at once into pint glass jars with glass covers, and processed in a pressure cooker for 70 minutes at 15 pounds. No salt was added. In feeding, a fresh jar was opened each morning. The liquid was handled the same as in the case of the commercially canned spinach.

The pigs used in this test were not in the best of physical condition when they arrived. The shipment was received in very cold stormy weather. At the first weighing the pigs ranged from 205 grams to 384 grams with an average weight of 294 grams. The pigs were kept three weeks before putting them on the experiment. During this time a number died of pneumonia and several more were culled. Those put on the experiment made an average daily gain of four grams during the preliminary feeding period. There was a range in weight of 300 to 473 grams and an average of 366 grams, which means that some of the animals were a little large for ideal testing.

CANNED SPINACH AND CANNED SWISS CHARD

Under general conditions is given the rating which might be made by any casual observer. Under autopsy are recorded the findings of the post-mortem. In most of the work with spinach and Swiss chard some conditions were let pass which in diagnosing later would have been interpreted as symptoms of scurvy. The microscopic examination of the bone is taken as the final decision. Normal equals N; possible scurvy equals ?; slight scurvy equals SS; scurvy equals S; advanced scurvy equals Ad S; and a line equals no examination made.

TABLE I

		Weight of Animals During Test Period			Gain or Loss	Days on Exp't	General Cndition	Autopsy	Misc. Exam.
Number	Food	Init.	Max.	Final					
Home Canned Spinach (Spinach bought in market)									
A 4	10 gms	473	619	566	93	90	Good	T	
A 5		373	431	298	-75	69	Poor	?	
A 6		330	405	360	30	90	Fair	?	
A 7		381	555	546	165	90	Good	N	
A 8		389	563	316	-73	90	Poor	?	S
A 9	5 gms	338	398	278	-60	48	Poor	?	
A 11		345	484	470	125	90	V. G.	N	
A 47		221	308	289	68	90	Fair	S	
A 48		294	386	290	-4	90	Poor	Ad S	
A 49		279	402	234	-45	90	Poor	Ad S	
A 12		421	597	307	-114	71	Poor	S	
A 13		375	414	372	-3	59	Poor	S	
A 14		301	465	321	20	69	Poor	S	SS
A 16		404	551	344	-60	90	Poor	Ad S	
A 17		395	504	407	12	90	Poor	S	?
A 18		352	517	302	-50	69	Poor	S	S
A 19		350	458	277	-73	59	Poor	S	
A 51		269	338	212	-57	67	Poor	S	
A 53		225	304	192	-33	90	Poor	Ad S	
Commercially Canned Spinach									
A 28	10 gms	400	595	534	134	90	Ex	N	
A 29		335	431	405	70	90	Good	?	
A 30		317	309	241	-76	66	Poor	S	
A 32		373	576	568	195	90	Ex	N	
A 33		395	518	464	69	90	Fair	S	N
A 34	5 gms	407	515	470	63	90	Fair	N	Ad S
A 58		241	427	427	186	90	Good	N	
A 59		255	400	398	143	90	Good	?	
A 60		316	534	515	199	90	Good	N	
A 61		246	411	382	136	90	Fair	?	
A 35		410	630	612	202	90	Good	N	
A 36		318	508	500	182	90	Good	N	
A 37		334	390	390	56	90	Fair	N	
A 38		366	521	448	82	90	Good	N	
A 39		369	616	616	247	90	Ex	N	
A 40		368	467	430	62	90	Good	N	S
A 41		376	379	207	-169	62	Poor	S	S
A 62		247	350	226	-21	90	Poor	S	
A 64		281	472	460	179	90	Good	N	N
Home-grown and Home-canned Spinach									
1	10 gms	456	617	599	143	69	Good	S	SS
2		426	715	715	289	90	Ex	?	SS
3		398	598	595	197	90	V. G.	SS	SS
4		406	520	510	104	90	Good	N	N?
5		338	515	497	159	90	Good	N	SS
6		348	427	415	67	69	Good	S	
7		355	454	432	77	90	Fair	?	
8		317	462	442	125	90	Good	T	SS

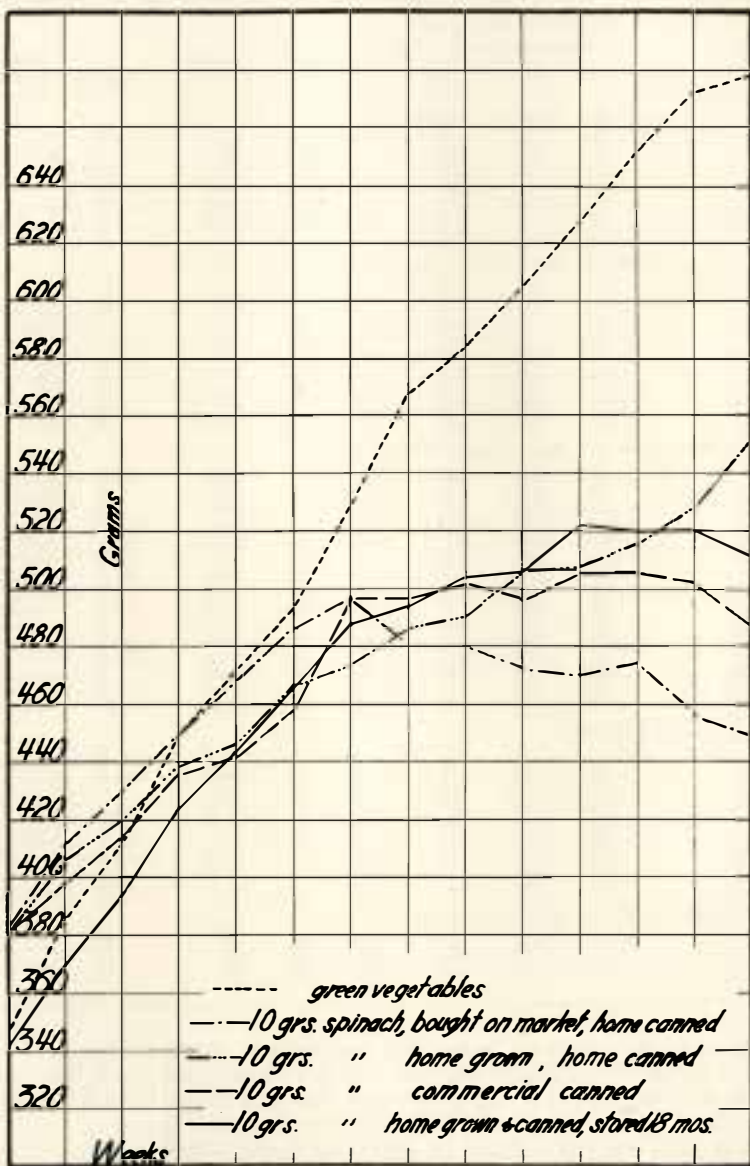
TABLE 1 (Cont.)

Weight of Animals During Test Period									
Number	Food	Init.	Max.	Final	Gain or Loss	Days on Exp't	General Condition	Autopsy	Misc. Exam.
Home Grown and Home Canned Spinach									
9	5 gms	468	676	645	177	90	Good	S	S
10		400	532	486	86	90	Good	?	S
11		365	504	501	136	69	Good	SS	SS
12		402	479	409	7	90	Fair	?	S
13		348	456	404	56	50	Fair	S	S
15		387	472	410	23	90	Fair	S	S
16		333	430	424	91	90	Fair	S	S
Home Grown and Home Canned Spinach—Stored 1½ years									
129	10 gms	350	482	472	122	90	Good	S	S
130		344	560	418	74	90	Fair	S	Ad S
131		392	588	580	188	90	Good	S	Ad S
132		344	510	380	36	90	Poor	Ad S	Ad S
133		360	592	592	232	90	V. G.	S	S
134		340	480	454	114	90	Fair	S	Ad S
135		364	596	578	214	90	Good	?	SS
136		302	670	610	368	90	Ex	N	?
137		300	485	458	158	90	Fair	S	Ad S
Home Grown and Home Canned Swiss Chard									
25	10gms	433	529	345	-88	67	Poor	Ad S	-----
26		406	513	328	-78	69	Poor	S	-----
27		395	500	272	-123	74	Poor	S	-----
29		359	440	284	-75	90	Poor	S	S
30		315	448	271	-44	76	Poor	Ad S	Ad S
31		384	540	426	42	90	Fair	Ad S	Ad S
32		337	405	220	-117	62	Poor	Ad S	-----
33	5 gms	430	566	420	-10	69	Poor	Ad S	Ad S
34		421	537	346	-75	69	Poor	Ad S	-----
35		395	499	432	37	90	Poor	S	-----
36		305	324	214	-91	65	Poor	Ad S	-----
37		371	444	306	-65	60	Poor	Ad S	-----
38		310	336	219	-91	39	Poor	S	-----
39		390	415	274	-116	55	Poor	Ad S	-----
40		344	454	326	-18	60	Poor	Ad S	-----
Negative Controls									
49		373	418	348	-25	37	Poor	S	-----
50		338	406	247	-91	55	Poor	Ad S	-----
51		299	429	390	91	32	Fair	S	-----
A 1		404	501	390	-14	45	V. P.	Ad S	Ad S
A 2		300	406	298	-2	45	V. P.	Ad S	Ad S
A 3		340	434	335	-5	43	Poor	Ad S	Ad S
A 42		273	280	243	-30	41	V. P.	Ad S	-----
A 43		251	331	202	-44	41	V. P.	Ad S	-----
A 44		239	269	202	-37	37	V. P.	Ad S	-----
Positive Controls—Green Vegetables									
52		355	663	663	308	90	Ex	N	-----
54		430	800	790	360	90	Ex	N	-----
55		381	700	700	319	90	Ex	N	N

Six pigs were given a basal diet; two showed unmistakable signs of scurvy on the thirty-fourth day and four on the thirty-seventh day. All began to lose weight on or before the day that they showed marked indications of scurvy. Two lived until the forty-fifth day.

Ten pigs were placed on 10 grams of home canned spinach. Two died before the end of the experimental period and all began to lose in weight on or before the seventy-first day. Histological determination was made of only one in the group and it revealed scurvy. There were positive indications of scurvy in three pigs during the test period.

CHART I



Spinach, Swiss chard and green vegetables.

The growth curves in Chart I represent the average for each group at the end of each week.

Autopsy showed five as questionable and two as normal. It is therefore safe to assume that ten grams of this product is not a protective dosage.

Nine animals were given five grams of this spinach. All developed scurvy as is shown by the accompanying table (Table 1). Three lived through the experimental period but were typical scurvy pigs. All were losing weight by the end of the sixth week.

Ten pigs were fed 10 grams of commercially canned spinach. One died on the sixty-sixth day. He was often slow about eating his spinach, occasionally wasting a portion of it, hence could not be considered as a fair test for vitamin potency. The remainder of the group lived through the 90 days, making (as shown in Chart I), rather small gains, but showing no decided evidence of scurvy. Histological study was made of but two in this group, one being normal and the other revealing advanced scurvy.

Nine pigs were fed five grams of commercial spinach. All but one lived through the experimental period. Three of the group made very good and consistent gains. Two lost, weighing considerably less than their initial weight at the close of the 90 days. In both cases, autopsy revealed scurvy manifestations. Microscopic examination of the bones from three pigs showed two as scrobutic and one as normal.

The charts were made by taking the average for the group at the end of each week. In Chart I, it will be noted that the guinea pigs fed on commercially canned spinach made a much better growth than the ones fed on the spinach bought in the market and then canned in the laboratory.

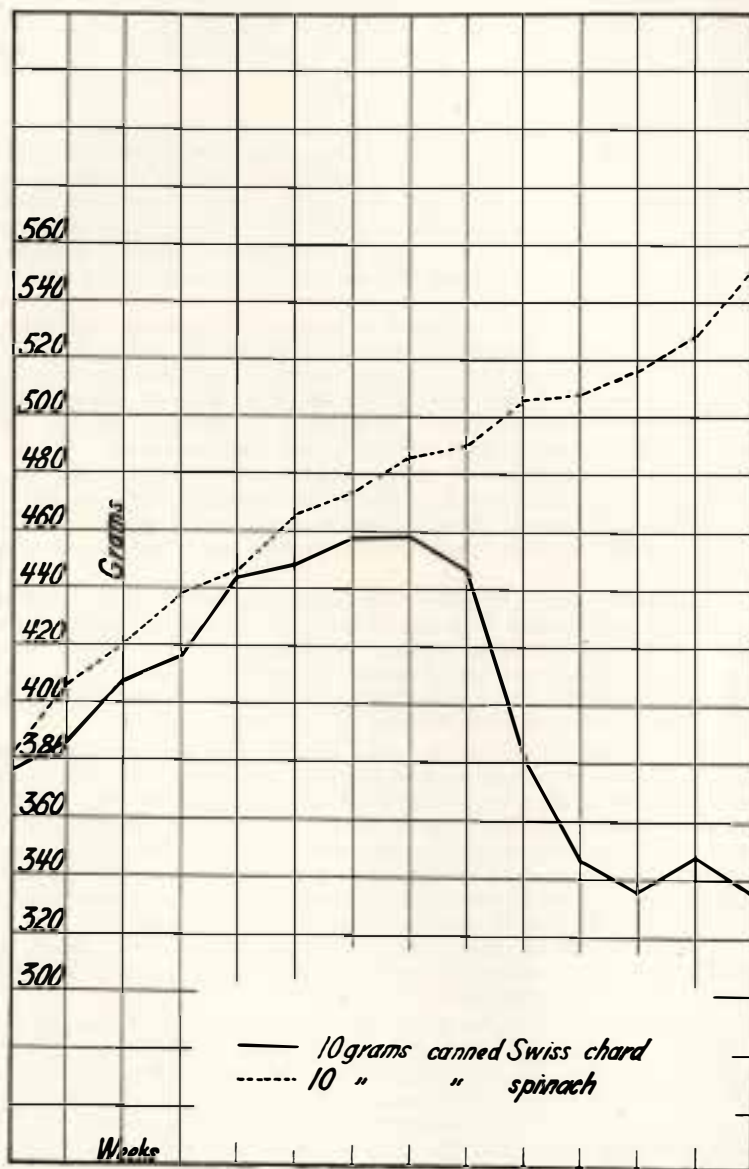
The question arose, whether the inferiority in Vitamin C potency was due to the method in home canning or to a deterioration in the spinach before the canning process. Accordingly, the following season home canned spinach was tested again. This time the spinach was grown in the college gardens, and canned the same day that it was picked. The same method was used as in the previous canning.

Eight pigs were fed 10 grams daily of this home grown, home canned spinach. Two of the group died on the sixty-ninth day, and both showed slight indications of scurvy. Histological determinations were made of six pigs in this group; five were pronounced to have had scurvy to a very slight degree, and the other was practically normal. The growth curves in Chart I indicate that this group made greater and more uniform gains than the group on commercially canned spinach and decidedly better gains than the earlier group on home canned spinach.

A year later, a year and a half after canning, this same spinach was tested in an effort to determine whether aging had caused a deterioration in the anti-scorbutic properties.

Nine pigs were given ten grams daily. These pigs on the whole were in very good condition judging from general appearances. Autopsy revealed slight indications of scurvy in all but one, and microscopic examination of the bones showed advanced scurvy in five. In the accompanying chart, the curve representing this test shows a decided tendency to drop towards the end of the period. This curve quite uniformly follows the commercially canned spinach, but falls below the home grown, home canned product that had been stored but a few months. This does not coincide with the findings of Eddy, Kohman and Holliday (24). They tested for the Vitamin C potency of spinach canned by commercial meth-

CHART II



Home grown, home canned spinach and Swiss chard.

The growth curves in Chart II represent the averages for each group at the end of each week.

ods, and stored for three years. In reviewing their work, they make the following statements: "Four grams daily were given as safe protective dosage for guinea pigs against scurvy in 1923-24. Retest of stored cans showed four grams still protective in 1926 and little significant difference in growth stimulation effect; the average in 1924 was 194 grams in 90 days, and in 1926, 154 grams. Scorbutic symptoms were absent."

The theory is generally accepted that there is not as great a loss in commercially canned products, as in home canned (21) because in the home method there is a free access of oxygen in the canning processes. Whether there is a relationship between the methods of canning and the effect of storage is a question.

There is an inconsistency in the Chart I and Table I. In charting the growth curve for the commercial spinach Numbers A 58, A 59, A 60 and A 61 were omitted in making the weekly averages for the group. If these were included it would tend to throw the points representing the last four weekly averages a trifle higher. This error was not noticed in time to make the change in the chart. Numbers A 47, A 48 and A 59 were omitted in charting the home canned spinach. Including them would have lowered the entire line, but made very little difference in the form of the curve.

Swiss chard is hardy and easily grown, is not as sensitive to frost as most green vegetables, is suitable for table use for a long period, and is rich in mineral matter. In a state where practically all of the vegetables for summer use are grown locally, and where the majority of families have their own gardens it seemed a happy thought to test Swiss chard for antiscorbutic properties, and, thus, undoubtedly add "rich in Vitamin C" to its advertised virtues. Collards, turnip greens (10) and spinach are rich sources of Vitamin C, and it seemed reasonable to expect that Swiss chard would be also. Accordingly it was tested both as a home canned product and a raw vegetable.

In the home canned, home grown Swiss chard, the same method was used as in preparing the spinach.

In the feeding test eight pigs were put on 10 grams and eight on 5 grams. Only two pigs on 10 grams and one on 5 grams lived through the 90-day period. All showed unmistakable symptoms of scurvy and many were in terrible condition. It is safe to conclude that as a source of Vitamin C canned Swiss chard should receive little or no consideration.

Some work was done in testing both spinach and Swiss chard cooked in the open kettle, but certain uncontrolled factors, and unfavorable conditions of the test animals leave the results without significance.

In order to determine to what extent the Vitamin C content was affected by canning, fresh raw spinach and Swiss chard were tested for potency. Both vegetables were grown in the same garden and under the same conditions as the vegetables used for the home canned products.

Eddy, Kohman and Carlson (20) state that one gram or less of raw spinach as purchased from a New York City market during the summer months was ample to meet the daily requirement of a guinea pig. Hessler and Craig (25) of the University of Missouri suggest from five to seven grams for protection.

The spinach used at South Dakota State College was grown in the college gardens and picked fresh each morning. It seemed fair to expect that this spinach would be equal to if not superior to that found in the city markets of New York, but such was not the case.

RAW SPINACH AND SWISS CHARD

Under general condition is the rating which might be made by any casual observer. Under autopsy are recorded the results of the post-mortem. The interpretation of the microscopic examination is accepted as the final decision. Normal equals N; questionable equals ?; slight scurvy equals SS; scurvy equals S; advanced scurvy equals Ad S; a line indicates that no examination was made.

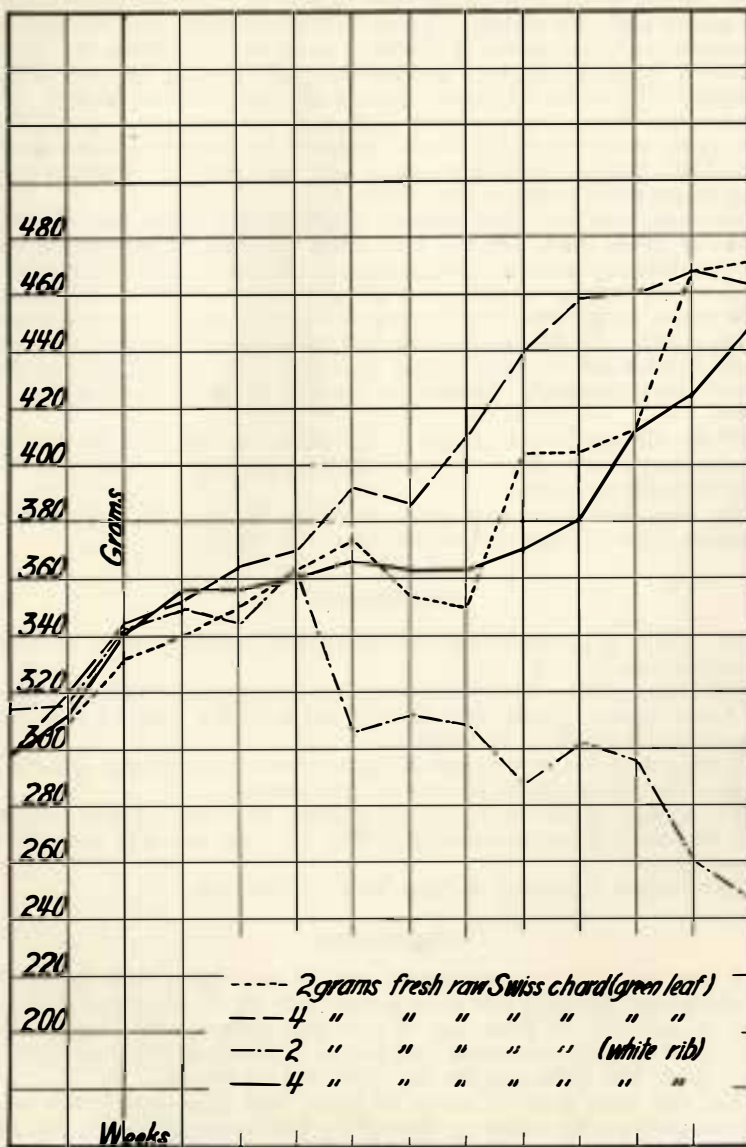
TABLE II

Number	Food	Weight of Animals During Test Period			Gain or Loss	Days on Exp't	General Condition	Autopsy	Misc. Exam.
		Init.	Max.	Final					
Fresh Spinach—Raw									
56	1 gm	294	480	480	186	90	Good	N	N
57		306	383	295	-11	90	Poor	SS	S
58		271	434	434	163	90	Good	?	SS
59		345	390	342	-3	90	Poor	S	SS
60		358	540	540	182	90	Good	N	SS
61		262	424	360	98	90	Good	S	Ad S
62		310	406	394	84	90	Poor	S	S
Swiss Chard, Green Leafy Portion—Fresh Raw									
83	2 gms	236	346	346	110	90	Fair	?	SS
84		359	460	460	101	90	Fair	S	Ad S
85		312	588	556	244	90	Good	?	S
86		316	372	264	-52	57	Poor	S	S
87		336	520	520	184	90	Fair	S	SS
88		234	278	202	-32	81	Poor	Ad S	-----
89	4 gms	258	350	266	8	90	Poor	Ad S	-----
90		325	350	300	-25	36	Poor	Ad S	-----
91		271	496	490	219	90	Fair	?	SS
92		292	568	568	266	90	Good	?	?
93		327	508	504	177	90	Fair	S	S
94		320	510	484	164	90	Fair	S	S
Swiss Chard, White Rib									
95	2 gms	295	330	268	-27	34	Poor	S	-----
96		272	318	210	-62	90	Poor	Ad S	-----
97		366	446	286	-80	90	Poor	Ad S	-----
98		347	471	444	97	41	Poor	S	-----
99		272	314	252	-20	39	Poor	S	Ad S
100		332	357	244	-88	32	Poor	Ad S	-----
101	4 gms	323	372	274	-49	48	Poor	Ad S	Ad S
102		420	550	540	120	90	Fair	S	Ad S
103		268	342	300	32	50	Fair	S	S
104		294	356	356	62	90	Poor	S	S
105		322	396	374	52	81	Poor	S	Ad S
106		248	337	322	74	76	Poor	S	SS
107		256	372	334	78	76	Poor	?	SS

Seven pigs were given one gram fresh spinach daily. All lived through the experimental period, three made fair gains and two weighed less at the final weighing than at the original. In general appearance there were no marked symptoms of scurvy, autopsy gave more or less evidence of insufficient Vitamin C, but histological examination indicated that one was about normal, three were slightly scorbutic, two had scurvy and one advanced scurvy. One gram of the fresh spinach used in this experiment could not be termed adequate protection.

As suggested elsewhere in this bulletin, it was anticipated that the Swiss chard would be rich in Vitamin C. For testing it was gathered fresh each morning from the college gardens. Chemical analysis was made in the department of chemistry. The green leafy portion was found to have 86.5 per cent moisture, 2.3 per cent ash, 11.1 per cent organic matter; the whole stem and rib 91.4 per cent moisture, 1.4 per cent ash

CHART III



Raw Swiss chard, the green leafy portion and white rib fed separately.

The growth curves in Chart III represent the averages for each group at the end of each week.

and 7.2 per cent organic matter. In using the raw Swiss chard the green leafy portion and the white rib were separated. Two groups were fed two grams and four grams of green leaf respectively; and two groups, two grams and four grams of the white stem and rib. Those fed on the white rib were always very anxious for their portion, and ate it immediately. Those on the green portion of the leaf were always slow about eating theirs. Two or three of them would have some of it left in their cages after five or six hours. However, on the whole those on the green leafy portion made better gains and were in better condition than those on the white stem and rib. Chart III.

Six pigs, with an initial average weight of 299 grams were fed two grams of green leafy portion. Four lived through the period, were in fair condition and made an average gain of 172 grams, but all had scurvy.

The same number of pigs were given four grams of the green leaf. Their initial weight was also 299 grams, but they made an average gain of 163 grams. All but one had marked symptoms of scurvy. That one nearly doubled his weight in ninety days, was in good condition; neither autopsy or microscopic examination showed positive manifestation of scurvy.

Of the six pigs on two grams of the white rib, two lived through the experimental period. Each weighed less than its initial weight, and was unquestionably scorbutic.

Six pigs were given four grams of white rib, and all of them were scorbutic. Four of them died before the end of the period.

Conclusions

Ten grams of commercially canned spinach does not afford complete protection from scurvy.

For home canning and consequently for cooking as a fresh vegetable, the home grown spinach has greater antiscorbutic potency than the spinach that is bought in the market.

A daily dosage of ten grams of home grown, home canned spinach is too near the border line to be classed as protective.

The spinach grown in the college gardens does not seem to have as high Vitamin C value as the spinach that has been tested in some other laboratories.

The Vitamin C potency of Swiss chard is very low.

Asparagus

A test was run on commercially canned asparagus, both the green and the white. A good grade of each was used. It was purchased in No. 1 cans, in case lots. A fresh can of each was opened each morning, the contents of the can was turned into a wire strainer and the juice drained into a bowl. The stalks and the juice were fed separately.

Ten pigs were given 10 grams of green asparagus stalk. As a rule, they ate their portions at once. During the first weeks frequently No. 110 would eat only a small amount of his daily dosage. He gained for a time, then lost, and his final weight was a trifle less than his initial weight.

Most of the others made very good gains, were in good condition at the end of the experimental period, and gave no outward evidence of scurvy. In the autopsy one was recorded as being scorbutic, one slightly scorbutic, one questionable, and seven as normal. Histological examination found two questionable, four to have slight scurvy, three scurvy and one advanced scurvy.

Microscopic examination is a finer method for discrimination than autopsy, hence the histological diagnosis is accepted as final.

Ten pigs were given ten grams of white asparagus. All the pigs lived through the 90 day period, were in very good condition and made good gains. In most cases the final weight is the maximum weight as is shown in Table III, or in other words, steady gains continued throughout the experiment. In autopsy two were thought to be possibly scorbutic, and eight about normal. By histological determination, one was pronounced possibly normal, four slightly scorbutic and four scorbutic. One had advanced scurvy.

Nine pigs were given 10 cc. of green asparagus juice. Two died before the close of the period. One had scurvy, the other some lung infection. The autopsy record shows one as scorbutic, three as possibly scorbutic, and five as normal. Histological diagnosis gives two as doubtful, one slightly scorbutic, and five as scorbutic. One had advanced scurvy.

Nine pigs were given 10 cc. of white asparagus juice. One pig died before the end of the period of a serious lung infection. With the exception of this one case, it is practically true to say that the final weight is the maximum weight. The autopsy record lists two as doubtful and seven as normal. The histological record shows five as doubtful and four as slightly scorbutic.

In general, the guinea pigs fed on asparagus, whether white or green, juice or stalk, made good growth and were in good condition. In Chart IV, it will be noted that the pigs fed asparagus stalks did not gain as rapidly after the tenth week. The group fed on the green juice made good and consistent gains. The group fed on the white juice made the best gains of any of the pigs in the asparagus test. The drop in the growth curve during the ninth week is due to the fact that pig No. 160 was sick (lung infection) and lost weight rapidly. While all the groups in the asparagus test made good gains and were in very good condition they fell far short of reaching the optimum growth of the pigs fed on green vegetables.

Conclusions

Among canned vegetables asparagus ranks high in its antiscorbutic potency.

The juice of canned asparagus is as rich in Vitamin C as the solid portion.

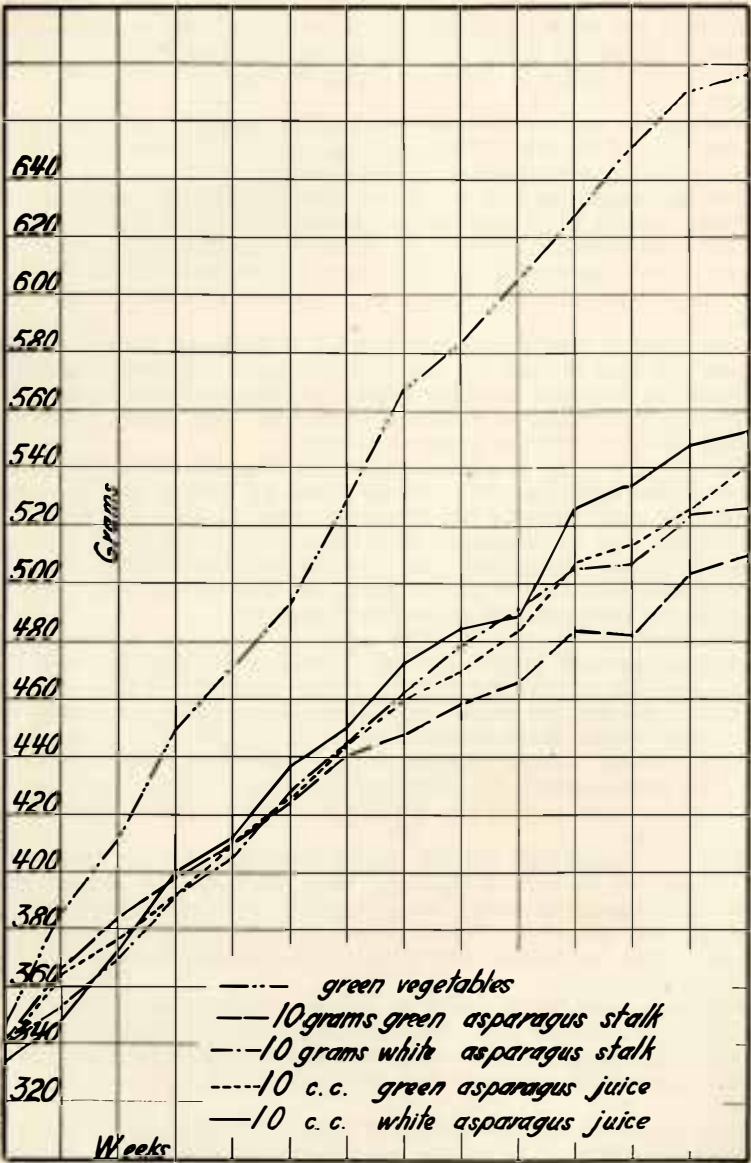
CANNED ASPARAGUS

Under general condition is the rating which might be made by any casual observer. Under autopsy are recorded the results of the post-mortem. The interpretation of the microscopic examination is accepted as the final decision. Normal equals N; questionable equals ?; slight scurvy equals SS; scurvy equals S; advanced scurvy equals Ad S; a line indicates that no examination was made.

TABLE III

Number	Food	Weight of Animals During Test Period			Gain or Loss	Days on Exp't	General Condition	Autopsy	Misc. Exam.
		Init.	Max.	Final					
Green Asparagus Stalks									
108	10 gms	320	348	330	10	90	Poor	SS	S
109		350	422	416	66	90	Good	N	SS
110		368	432	362	-4	90	Fair	SS	S
111		426	774	774	348	90	Ex	N	SS
112		334	596	594	260	90	Ex	N	SS
113		320	467	460	140	90	V. G.	N	S
114		324	574	574	250	90	Ex	N	?
115		364	650	650	286	90	Ex	N	SS
116		296	394	394	98	90	Fair	?	Ad S
117		312	544	544	232	90	Ex	N	?
White Asparagus Stalks									
118	10 gms	346	469	460	114	90	Good	N	SS
119		320	520	520	200	90	Ex	?	S
120		336	603	602	266	90	Ex	N	SS
121		392	568	568	176	90	Good	N	S
122		356	485	476	120	90	Good	?	Ad S
123		332	613	602	270	90	Ex	N	S
124		380	672	672	292	90	Ex	N	SS
125		342	416	412	70	90	Fair	N	S
126		318	586	586	268	90	Ex	N	?
127		276	366	366	90	90	Ex	N	SS
Green Asparagus Juice									
138	10 cc	316	322	298	-18	84	Poor	S	Ad S
139		316	486	486	170	90	Fair	?	S
140		332	482	482	150	90	Fair	N	S
141		360	500	464	104	74	Good	N	?
142		348	566	564	216	90	Good	N	?
143		325	614	614	289	90	Good	?	S
144		390	522	522	132	90	Good	N	S
145		379	614	610	231	90	Ex	N	SS
146		272	494	494	222	90	V. G.	?	S
White Asparagus Juice									
152	10 cc	322	404	404	82	90	Fair	N	?
153		300	436	436	136	90	Fair	?	S
154		344	644	612	268	90	Good	N	S
155		376	538	526	150	90	V. G.	N	?
156		336	586	586	250	90	Ex	N	S
157		376	648	648	272	90	Ex	N	?
158		366	610	610	244	90	Ex	N	?
159		324	606	596	272	90	Ex	N	?
160		270	436	360	90	65	Fair	?	S
Negative Controls Basal									
147		274	382	190	-84	44	S	Ad S	Ad S
148		256	280	234	-22	25	S	Ad S	-----
Positive Controls Green Vegetables									
149		264	625	600	336	90	Ex	N	-----
150		312	644	638	326	90	Ex	N	N

CHART IV



Asparagus

The growth curves in Chart IV represent the averages for each group at the end of each week.

Carrots

A study was made of the Vitamin C content of home canned carrots, of carrots pulled the middle of August and put in cold storage, and of mature carrots pulled in October, packed in sand and stored in a root cellar.

The summer was very hot and dry, and the August carrots were small for that time of the year. The canned and the cold storage carrots were from the same garden, gathered at the same time.

For the canned product, the carrots were canned the same day that they were pulled. They were washed, scraped and sliced, then canned by the hot-pack method suggested in Farmer's Bulletin No. 1471 of the United States Department of Agriculture. They were packed in glass pint jars and processed 35 minutes at 10 pounds pressure. No salt was used.

One group of four guinea pigs was fed 10 grams of the raw August carrots. All lived through the experimental period and were in excellent condition. In each case the final weight was the maximum weight. The histological determination gave one as normal; one, doubtful and one slightly scorbutic. One had advanced scurvy.

One group was fed 10 grams and another 15 grams of the raw stored carrots pulled in October (41). On the whole, all were in very good condition. The ones receiving the 10 grams made as good and consistent gains as the ones on 15 grams. Microscopic examination found that one on the 10 grams was normal; one, questionable; two, slightly scorbutic and one scorbutic. On the fifteen grams, one was normal; one questionable; and one scorbutic. One had advanced scurvy.

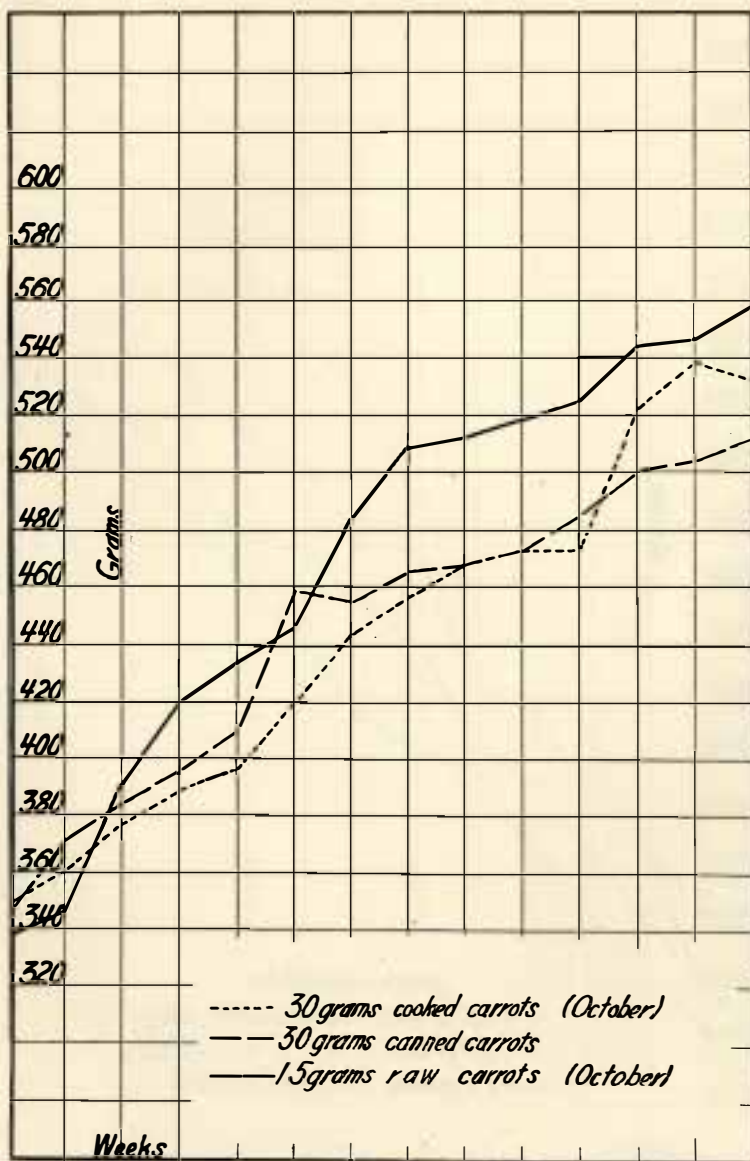
One group of five was given 20 grams of home canned carrots and another was given 30 grams. A fresh can was opened each morning. The contents of the jar was turned into a wire strainer and the juice was discarded. All but one made big and consistent gains throughout the ninety day period. Each appeared to be in a good state of nutrition. Autopsy revealed a slight tendency toward scurvy in all but three cases, and those were doubtful. The histological record of the pigs receiving 20 grams gave one as normal, two slightly scorbutic and two as having advanced scurvy.

Both the August and October carrots were cooked in an open kettle and tested for Vitamin C potency. They were washed, scraped and cooked until tender in enough water to cover. Most of the carrots were small and were left whole. The large ones were cut in two or three pieces. A fresh supply was cooked each morning. The carrots were drained and the liquid discarded.

Four pigs were fed 20 grams of August carrots, cooked. They made consistent gains in each case. The final weight was the maximum weight. All were in good condition. Autopsy revealed indications of scurvy. Microscopic examination showed that two had scurvy and two advanced scurvy.

Four pigs were given 20 grams of October carrots, cooked, and five were given 30 grams. All but one made big gains and were in excellent condition at the end of the experiment. As will be noted in Table IV, autopsy gave no decided indications of scurvy in eight of the pigs. Of the ones receiving 20 grams histological determination found one normal; one questionable; one slightly scorbutic and one scorbutic. Of the ones

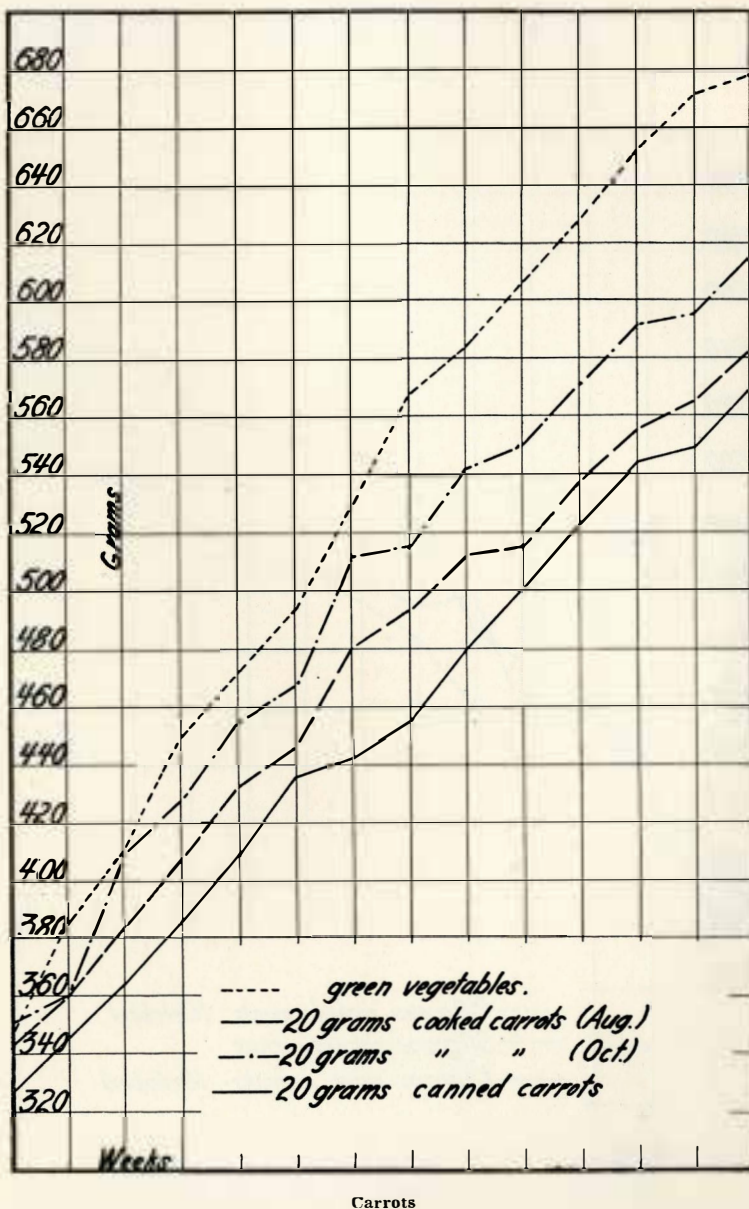
CHART V



Carrots

The growth curves in Chart V represents the averages for each group at the end of each week.

CHART VI



The growth curves in Chart VI represent the averages for each group at the end of each week.

CARROTS

Under general condition is the rating which might be made by any casual observer. Under autopsy are recorded the results of the post-mortem. The interpretation of the microscopic examination is accepted as the final decision. Normal equals N; questionable equals ?; slight scurvy equals SS; scurvy equals S; advanced scurvy equals Ad S; a line indicates that no examination was made.

TABLE IV

Number	Food	Weight of Animals During Test Period			Gain or Loss	Days on Exp't	General Condition	Autopsy	Misc. Exam.
		Init.	Max.	Final					
Raw Stored Carrots (August)									
161	10 gms	376	624	624	248	90	Ex	N	N
162		368	612	612	244	90	Ex	?	?
163		286	430	430	144	90	Ex	N	Ad S
165		366	498	498	132	90	Ex	N	SS
Raw Stored Carrots (October)									
170	10 gms	342	556	556	214	90	Ex	?	SS
171		410	702	702	292	90	Ex	N	S
172		294	460	452	158	90	Fair	?	N
173		318	470	470	152	90	V. G.	N	SS
174		354	556	550	196	90	Ex	?	?
175	15 gms	378	488	476	98	90	Ex	?	?
176		392	630	630	238	90	Ex	N	N
177		284	498	498	214	90	Ex	SS	SS
178		342	420	366	24	70	Fair	SS	Ad S
Canned Carrots									
179	20 gms	378	576	576	198	90	Ex	?	SS
180		388	666	666	278	90	Ex	SS	Ad S
181		264	490	490	226	90	Good	SS	N
182		314	548	548	234	90	Good	SS	Ad S
183		296	556	556	260	90	Good	S	SS
184	30 gms	340	494	494	154	90	Good	SS	SS
185		392	584	572	180	90	Good	S	SS
186		352	548	548	196	90	Good	SS	S
187		326	558	558	232	90	Ex	?	S
188		326	446	386	60	90	Fair	?	Ad S
Cooked Carrots (August)									
189	20 gms	328	570	570	242	90	Good	SS	Ad S
190		404	578	578	174	90	Good	SS	S
191		320	638	638	318	90	V. G.	S	S
192		324	542	542	218	90	V. G.	S	Ad S
Cooked Carrots (October)									
198	20 gms	340	650	650	310	90	Ex	SS	S
199		382	450	450	68	28	Fair	?	SS
200		354	518	518	164	90	Ex	N	N
201		332	676	676	344	90	Ex	N	?
202	30 gms	346	606	606	260	90	Ex	N	Ad S
203		368	600	586	218	90	Ex	?	?
204		284	420	416	132	90	Ex	N	N
205		338	550	550	212	90	Ex	?	SS
206		356	634	634	278	90	Ex	N	N
Negative Controls									
207		270	362	346	76	28	Fair	Ad S	Ad S
208		346	410	388	42	40	Fair	S	S
209		296	312	200	-96	38	Poor	Ad S	S

receiving 30 grams, two were normal; one questionable and one slightly scorbutic. One had advanced scurvy.

In this experiment it was no problem to get the guinea pigs to eat their daily portions; regardless of the size of the dosage, cooked or raw, the full amount was eaten without protest.

The animals were healthy and in good condition. The growth curves in Charts V and VI indicate steady gains. The weights tabulated in Table IV, do not indicate that any one group had made particularly better gain than any other group.

Autopsy and histological determination indicate that all portions fell below a protective dosage, and that the August carrots, the cooked and the canned carrots, both the 20 grams and 30 grams, are a little lower in Vitamin C potency than the other portions.

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