A study of the effect of storage upon the vitamin C content of potatoes grown in Gallatin valley
by Erlene Jacobs

A thesis submitted to the Graduate Committee of Montana State College In partial fulfillment of the requirements for the degree of Master of Science 1927
Montana State University
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Abstract:
1 2.5 grams of raw potato daily did not give guinea pigs adequate protection against Scurvy.

2. 5 grams of raw potato daily were equivalent to 3 ec of orange juice in their antiscorbutics value.

3. 10 and 30 grams of raw potato daily appeared to he similar to 5 grams of raw potato in their antiscorbutic value and support of growth, 4. There is some evidence that only a certain amount of vitamin C in potato is utilised by the guinea pig, 5. After six months storage under excellent conditions there ap-peared to be no loss of vitamin C in potatoes.

6. The cooking of potatoes in the early period of storage reduced the potency of vitamin C to one-fourth its original value.

7. After six months storage there were indications that some change had occurred in the- potato so that the cooked product seemed to have almost as beneficial an effect upon the growth of guinea pigs as the raw stored potato, CONCLUSION When potatoes raised in Gallatin Talley were stored during the winter of 1926-1927 under the following conditions? average relative humidity, 95% average temperature, 3.5°C; and good ventilation, there was no deterioration in their vitamin C content.

A STUDY OF THE EFFECT OF STORAGE UPON THE VITAMIN C CONTENT OF POTATOES GROWN IN GAILLATIN VALLEY.

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A STUDY OF THE EFFECT OF STORAGE UPON THE VITAMIN C CONTENT OF POTATOES GROWN IN GALLATIN VALLEY.

INTRODUCTION

Since the eighteenth century, the white potato has become the vegetable most commonly used by the American people. In general this popularity might be attributed to the fact that potatoes are easily grown, stored or shipped and are usually inexpensive. McCollum believes that their extensive use may also be traced to their lack of any pronounced characteristic flavor.

From a nutritional standpoint, however, they have proved to be a very good source of food materials. Investigators have done a great deal of work in studying the composition of different varieties of potatoes and have found them to be high in caloric value, well supplied with base forming elements and a medium source of the vitamins A, B and C.

It is doubtless due to the presence of the latter food factor, vitamin C, that the potato occupies an important place in the diet of many people. This is the food factor which prevents the disease, scurvy, and helps to promote normal growth. While vitamin C is found abundantly in many fresh fruits and vegetables, these are often too expensive to be commonly used during the winter

45222

months. Therefore, the potato, with only a moderate amount of vitamin C, is used to such a relatively large extent in daily diets, that it serves as one of the best antiscorbutic foods for the winter season.

It has been recognized for some time that certain physical and chemical changes take place within the potato during the period of winter storage. Such changes have been noted as shrivelling and variations in the percentage of water, starch and sugar. However, no one has yet determined whether storage has any effect upon the vitamin C content of potatoes. A few investigations have been carried on to show the effect of storage upon the vitamin content of apples, and there are some indications that storage has a deleterious effect upon vitamin C. It therefore, seemed advisable to carry on a similar study with potatoes to determine whether winter storage might have an effect upon their antiscorbutic value.

HISTORY.

In a review of the literature it was noted that, as far back as the thirteenth century, scurvy was recognized as being caused by a lack of fresh vegetables or fruit in the diet. The evidences for this fact were derived from numerous experiences of soldiers and sailors who were deprived of fresh foods for long periods of time. However, when the culture of the potato was introduced into Europe, there was a resulting decrease in the occurrence of scurvy (1).

While a faulty diet was considered the cause of a scorbutic condition, no specific factor in this diet was known to be related to the disease. When in 1907, Holst and Frolich fed a group of

guinea pigs on carrots, turnips or dandelions, and another group on cereals and bread, and accidentally produced scurvy in the latter group, they were led to the idea that the cause was a specific nutritional one.

From this time on, investigators began to develop various theories regarding the etiology of scurvy. Jackson and Moore (2) 1916, presented the infection theory, and McCollum and Pitz (3) 1917, advocated constipation and injury to the cecum as the cause of scurvy. Some later work done by Chick, Hume and Skelton, (4) 1918, and Cohen and Mendel (5) 1918, showed that the lack of a specific factor in the diet was responsible for the occurrence of scurvy. This factor was designated as "Vitamin C" by Drummond in 1920.

Since that time many investigators have been interested in studying vitamin C to find out in what foods it occurred, and in what amounts it was present. It has also seemed very important to determine what factors might effect the potency of this antiscorbutic vitamin.

Feeding experiments have shown oranges, lemons, tomatoes and raw cabbage to be among the richest sources of vitamin C. Kohman (6) claims that a guinea pig is generally regarded as needing 1.5 cc of fresh orange juice daily to supply its needs of the antiscorbutic vitamin. Hardin and Zilva (7) found that 2 to 5 cc of orange juice per day were required to protect a guinea pig of 300 to 400 grams. Kohman (6) also states that 1.0 to 1.5 grams of raw cabbage are sufficient to supply a guinea pig with vitamin C and Sherman (1) says that with 3 cc or more of

tomato juice per day there is complete protection from scurvy.

Potatoes, apples, carrots and bananas do not contain as much of vitamin C, but are important as antiscorbutics as they are eaten in larger quantities. Givens and McCluggage (8) found that 10 grams of raw potato daily protected animals against scurvy. Givens and co-workers (9) found 10 grams of raw apple to be a minimum protective dose. Lewis (10) states that 25 grams of raw banana is sufficient for the guinea pig.

Sherman (1) has also worked out a table showing the relative richness in vitamin C of certain fruits and vegetables compared with orange juice as 100.

Apple, raw	10-20
Banana, raw	20-40
Cabbage, raw	100
Cabbage, fully cooked	5-10
Orange juice	100
Potatoes, raw	50 (?)
Potatoes, cooked	10-30
Tomatoes	100

It will be observed in the preceding table that there is a loss in the vitamin potency of potatoes during cooking. This loss appears to be due to oxidation with some relation to the time and temperature of heating. Kohman (6) of the National Canners Association has summarized the existing data, showing the effect of heat on Vitamin C in potatoes (Table I).

TABLE I.

The Effect of Heat on Vitamin C in Potatoes.

reatment	Substance	Results	Authors
ntreated	Raw potato	10 grams per day per guinea pig protected from scurvy	Givens and McClugage.
ated 1/4 ur at 212°F.	Raw potato	10 grams daily gave equally as good protection as raw.	Givens and McClugage.
at 1 hour 212° F.	Raw potato	10 grams daily did not appreciably delay scurvy	Givens and McClugage.
Boiled	Potato	One tablespoonful more effective than one-half banana	Hess and Unger
eamed 1/2 ur at 212°F.	Potato	17 to 20 grams as effective as 1.5 to 3 cc orange juice	Chick and Rhodes.

Direct contact with oxygen during heating causes the greatest loss of the potency of vitamin C. This fact has been recognized by commercial canners. Schield (11) states that common canned corn, beans and peas contain considerable C but the vitamin content is increased 2 to 4 fold by removing the air before processing. Kramer (12) has found that the antiscorbutic factor in California pear is destroyed in the open-kettle method of canning but not completely destroyed by the cold pack method. The canning of tomatoes, however, seems not to have so much of an effect upon the antiscorbutic factor. Kohman (6) shows that from 3 to 5 cc of commercially canned tomato juice given daily were sufficient to prevent scurvy in a guinea pig. LaMer, Campbell and Sherman say that boiling this tomato

juice for one hour destroyed practically 50% of vitamin C. These facts are attributed to the presence of considerable natural acidity in the tomato pH 4.3.

Another characteristic of vitamin C which might be partially responsible for the loss of this vitamin during the cookery of potatoes, is its solubility in water. Considerable of the factor is dissolved away during cooking. Sherman (1) believes that the water may be expected to contain as high a concentration of the vitamin as does the solid part of the food.

Again, drying has been investigated as to its effect upon the stability of vitamin C. Harden and Robison (15) state that when orange juice was dried it retained most of its antiscorbutic properties even after a lapse of 2 years. This was accomplished when the juice was stored in a dry atmosphere at room temperature, but if it was kept at 29°C the factor was much more rapidly destroyed. Shorten and Ray (16) found that dried potatoes and cabbage retained much of their antiscorbutic values when fed as a daily ration of 5 grams of dried product to guinea pigs. Givens and McClugage (8) reported that animals are afforded some protection by potatoes dried in a blast of air at 55 to 60°C for 4 to 6 hours, but those dried at 75 to 80°C for 2 to 3 hours retained less of this property. Also potatoes first heated in the skins for 40 to 55 minutes at 204°C, then dried at 55 to 40°C afforded more protection than those dried at low temperatures only. This indicated that retention of the skin seemed to prevent some oxidation and the subsequent destruction of vitamin C.

This brings up the question as to whether the corky layer on the outside of the potato might also prevent the deterioration of the antiscorbutic factor during the long period of winter storage. It has

been found that the other desirable qualities of the potato are retained if it is carefully stored in cellars, pits or specially constructed and regulated store houses. (17). The optimum conditions for storage are a constant temperature of 4°C, a medium degree of relative humidity and good ventilation. However, even when the utmost care is taken there is a change in the percentage composition of the potato. Appleman (18) found that respiration converts the starch into sugar and also into CO_2 and H_2O.

It is altogether logical to question, then, whether winter storage might have some effect upon the vitamin C content of potatoes. Storage of a few other foods has been studied and some interesting facts noted. Kramer (12) found that storage of fresh pear seemed to make no difference in its antiscorbutic value. Delf (19) states that whole oranges, lemons and swede roots after 5 years in cold storage appeared to keep their antiscorbutic value as long as the material remained in good condition. Oranges and lemons stored 5 years in a frozen condition retained about half their antiscorbutic property but swede juice became almost inactive in 15 months. Davey (20) agreed with Delf when he found that oranges and lemons kept in a cool room but not frozen retained most of their antiscorbutic property so long as the fruit was edible.

These data point out the fact that very little definite information is to be found regarding a food so commonly stored and so extensively used as the potato. For this reason the present investigation seems particularly desirable in order to secure more knowledge which could be used in regulating dietary habits.

EXPERIMENTAL PROCEDURE.

In order to determine the effect of winter storage upon the vitamin C content of potatoes, series of animal feeding experiments were carried on at intervals of three months. Forty-nine guinea pigs of both sexes from six to eight weeks old and weighing from 200 to 400 grams were used as the experimental animals.

The method of procedure adopted by Sherman, LaMer and Campbell (1) was followed closely throughout the experiment. The animals were kept in individual cages under sanitary conditions. Their basal diet was prepared as follows:

Whole oats (ground as needed)	59%
Powdered skim milk (heated 2½ hrs at 110°C in contact with air to destroy vitamin C)	30%
Butter fat (rendered)	10%
NaCl	1%
	100%

These ingredients were thoroughly blended into a homogeneous mixture and stored in earthenware jars.

This basal diet was supplied 'ad libitum' to each of the experimental animals in small earthenware feeding dishes. As its extensive use by Sherman (1) and other investigators has shown that this diet contains all the food nutrients except vitamin C, it serves as a good scorbutic ration when fed alone. Therefore in each series, one control group of three guinea pigs was given only

the basal ration (Groups I and IX). Another control group in each series was given the basal ration plus a daily feeding of orange juice sufficient to protect the guinea pigs from scurvy and keep them growing and in a healthy condition. At first, each of these guinea pigs was given a daily dose of 2 cc. of fresh orange juice, but later it seemed advisable to increase this amount to 3 cc. daily (Groups II and X).

The other experimental animals were given varying amounts of raw and cooked potato as supplements to the basal ration, in order that their relative vitamin C content might be determined as compared with the basal ration alone, and the basal ration plus orange juice.

Each guinea pig in Groups III and XI received 2.5 grams of raw potato daily; in groups IV and XII, 5 grams of raw potato daily; in groups V and XIII, 10 grams of raw potato daily; in group VI, 20 grams of raw potato daily; in group XIV, 5 grams of cooked potato daily; in group VII and XV, 10 grams of cooked potato daily; and in group VIII, 20 grams of cooked potato daily.

The potatoes used for this experiment were of the Netted Gem variety and were grown three miles southeast of Bozeman on land which was irrigated once during the summer. Due to an early severe frost, they were dug Sept. 25, 1926 and kept in storage on the farm for three weeks before they were brought to the storeroom. Here they were picked over twice to separate any potatoes that might have been frozen.

The storeroom where these potatoes were kept was the one recently constructed by the horticulture department of Montana State College. Records kept throughout the winter showed an average rela-

tive humidity of 95% and an average temperature of 3.5 °C, with good ventilation. After six months storage in this storeroom, the potatoes seemed not to have changed to any noticeable degree in their physical properties.

The potato was prepared for feeding as follows:- if fed raw, the potato was peeled and quickly passed through a universal food chopper with a medium knife. The ground potato was mixed and weighed in the required amounts into small Pyrex ramekins which were at once given to the animals. When the potato was fed in a cooked condition, about half a medium potato was boiled for 25 minutes in 275 cc of boiling unsalted water, then drained, mashed, cooled and weighed out in the required amounts.

A daily record was kept of the amount of basal ration and special food consumed. Weights of each animal were taken and recorded twice per week and any abnormalities noted. Both series were continued over a period of nine weeks and growth curves were made in order to compare the relative conditions of the animals fed on different rations.

Many of the animals were autopsied to secure further evidence of their condition. Hemorrhages and swelling around the wrist and ankle joints, enlargement of the costochondrial junction, enlarged adrenals and looseness of teeth were expecially noted.

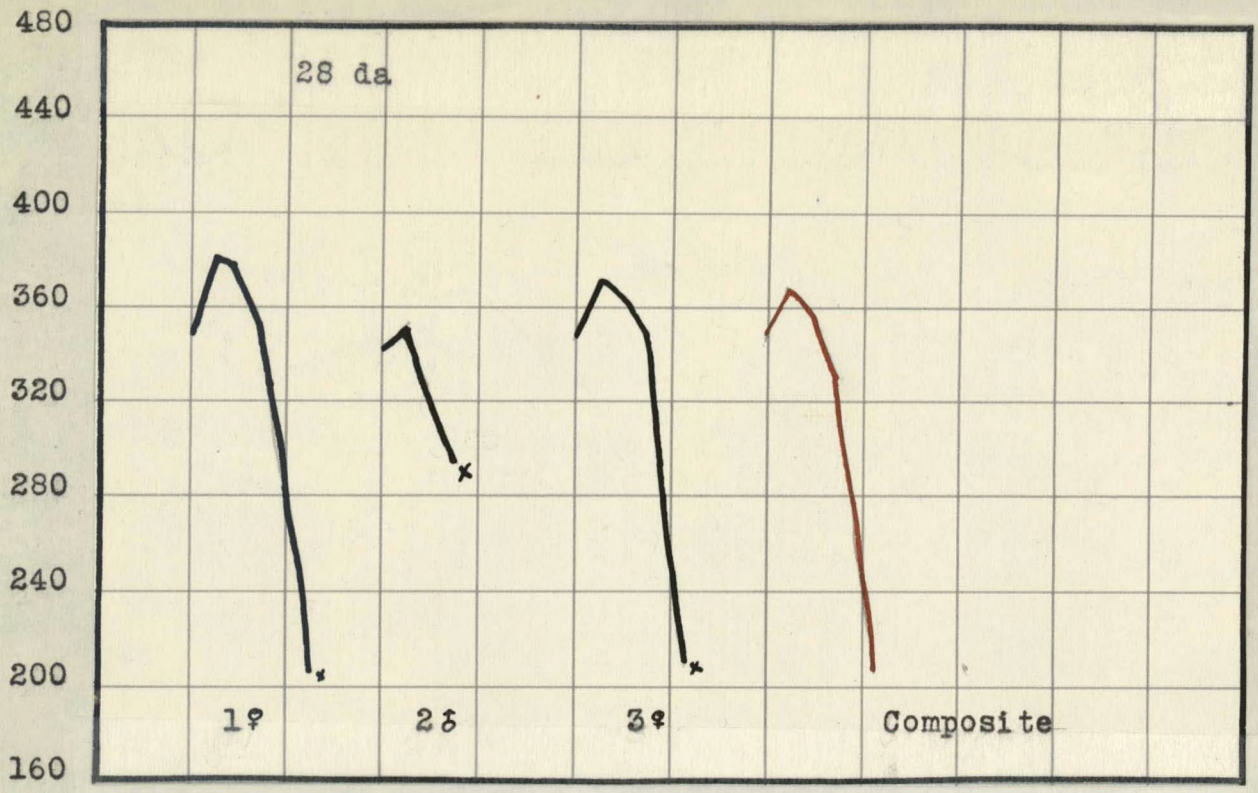
RESULTS.

In the first series of feeding experiments, the animals kept on the basal diet alone began to lose weight quite uniformly at the end of the first week. This decline in weight continued until death occurred at the end of 26-36 days (Fig. I). No outward signs of scurvy other than loss of body weight and a falling off of the appetite were noticed prior to their death. Upon autopsy, however, pronounced symptoms of scurvy were evident in addition to the general run down condition due to starvation. In all cases there were hemorrhages at the wrist and ankle joints and along the ribs, beading at the costochondrial junctions and enlargement of the adrenal glands.

The positive control group, fed on the basal diet plus 2 cc of fresh orange juice, was made up of one male and two females. The male grew at a fairly uniform rate throughout. The females, however, were more irregular so that at the seventh week 4 cc of orange juice were substituted for the 2 cc in all cases. From this time on, the females gained at the same rate as the male. (Fig. III).

The animals fed on the basal ration plus 2.5 grams each of raw potato daily showed a rather uniform decrease in weight at the end of five weeks. Notwithstanding their loss of weight, theyexhibited no symptoms of scurvy and were carried to the end of the experimental period. (Fig. V).

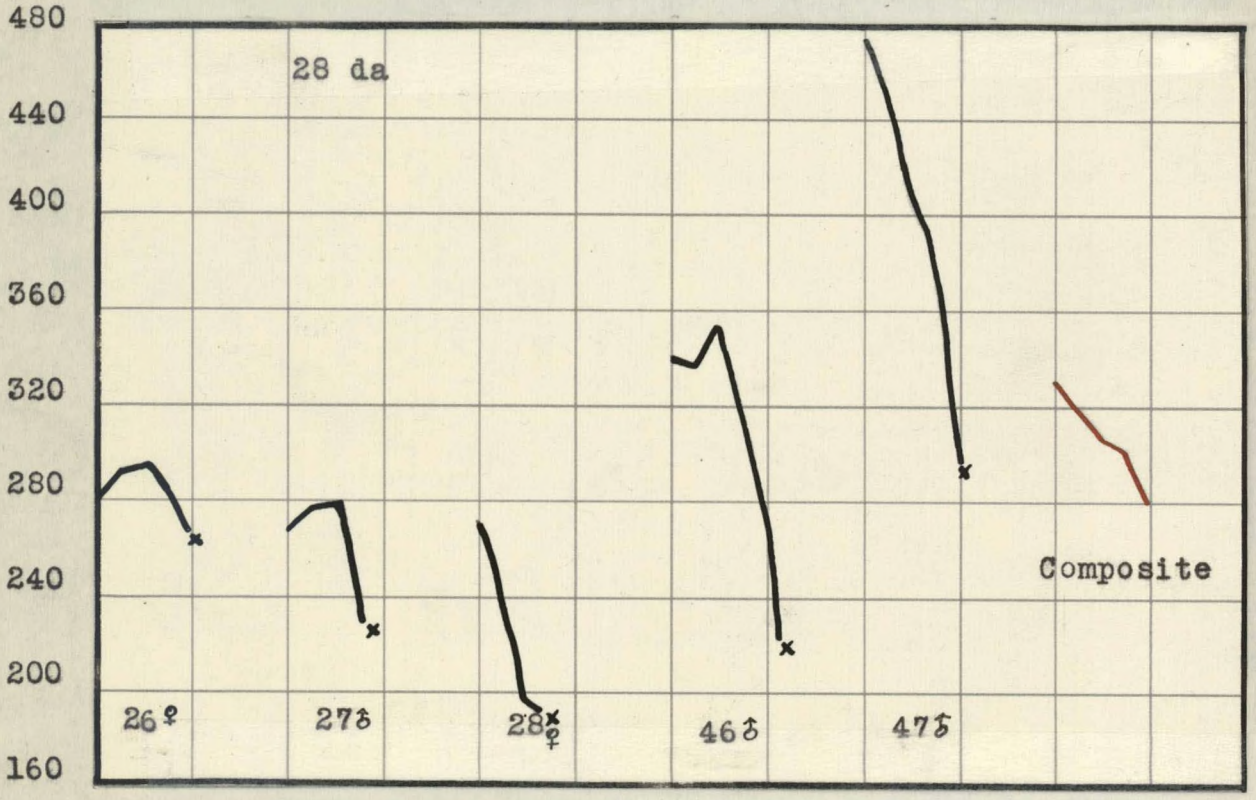
The group receiving 5 grams raw potato daily in addition to the basal ration, as a whole, grew at approximately the same rate as those on orange juice. Two of the animals manifested perfect health and stored fat normally, while the third one which was sick the first four weeks gained rapidly and steadily after that time. This sickness was



Series I, Group I.

Fig. I.

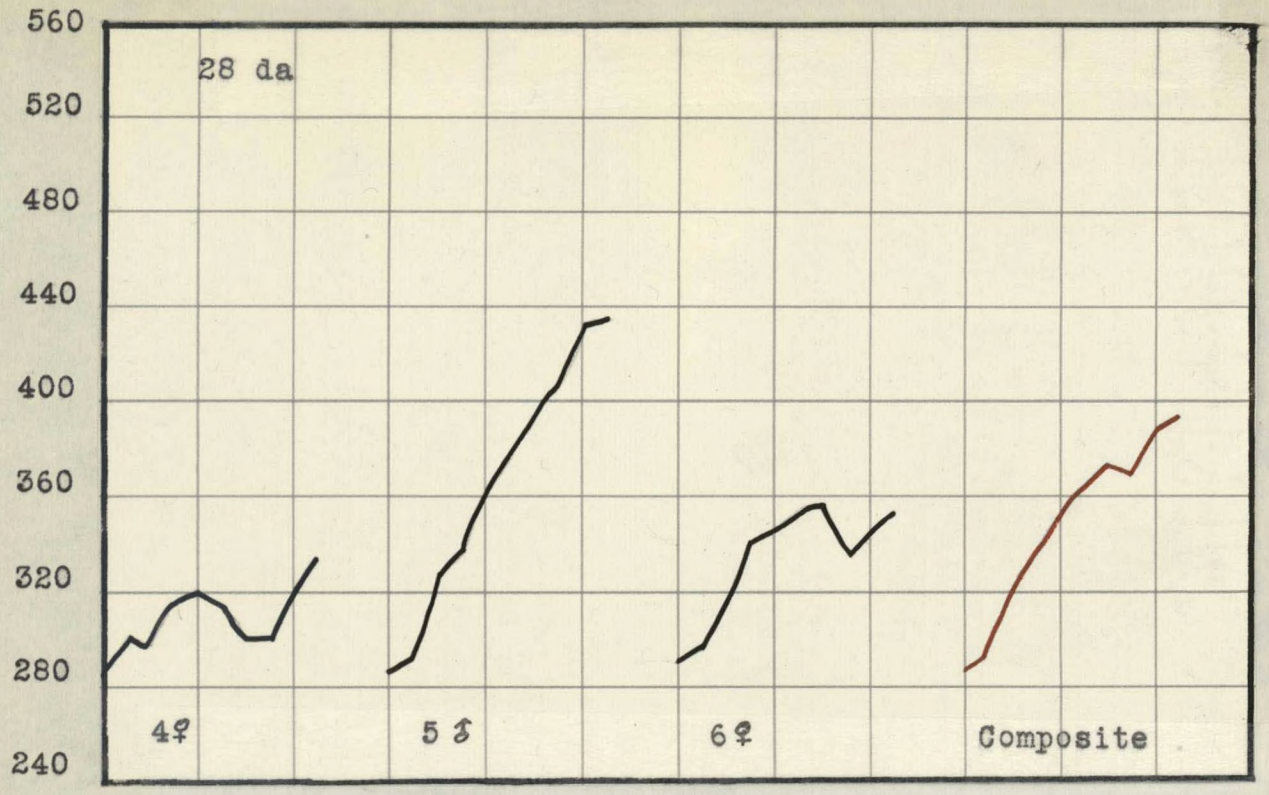
Growth Curves of Guinea Pigs Fed on Scorbutic Basal Ration.



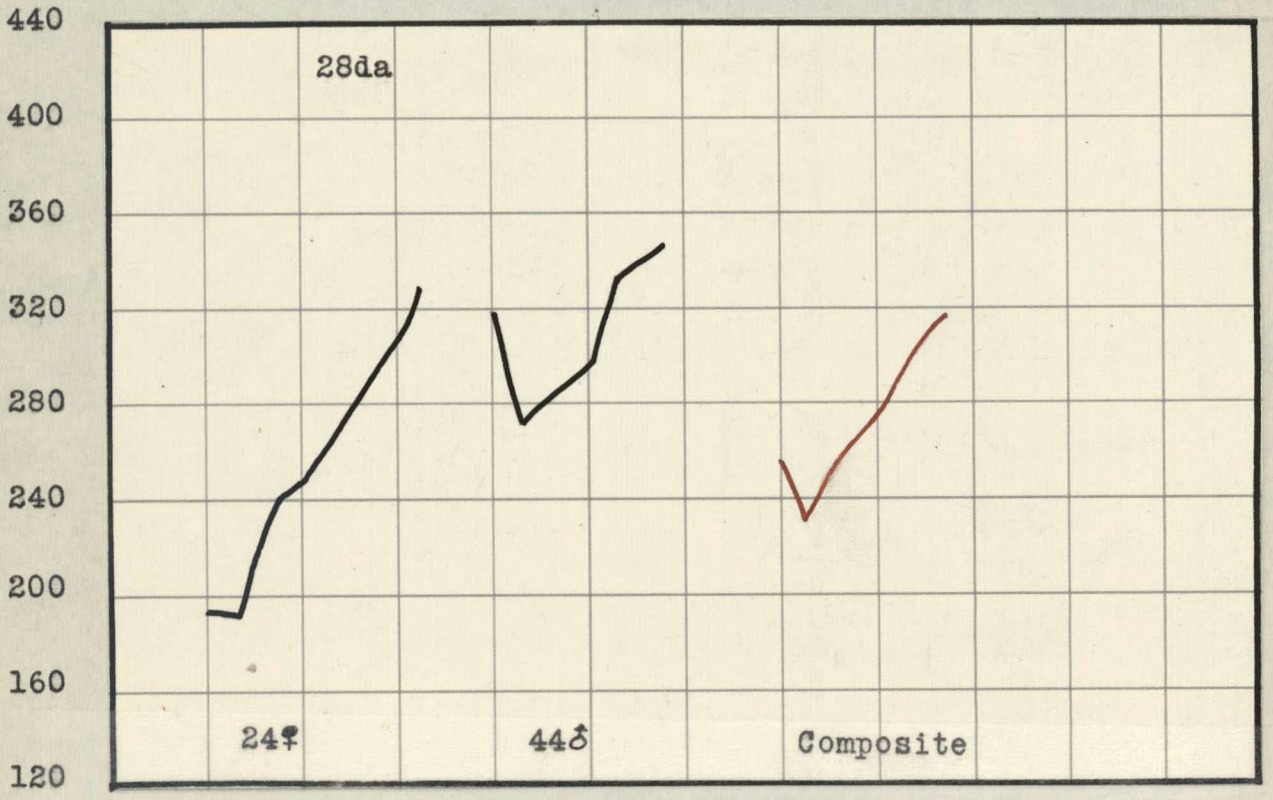
Series II, Group IX.

Fig. II.

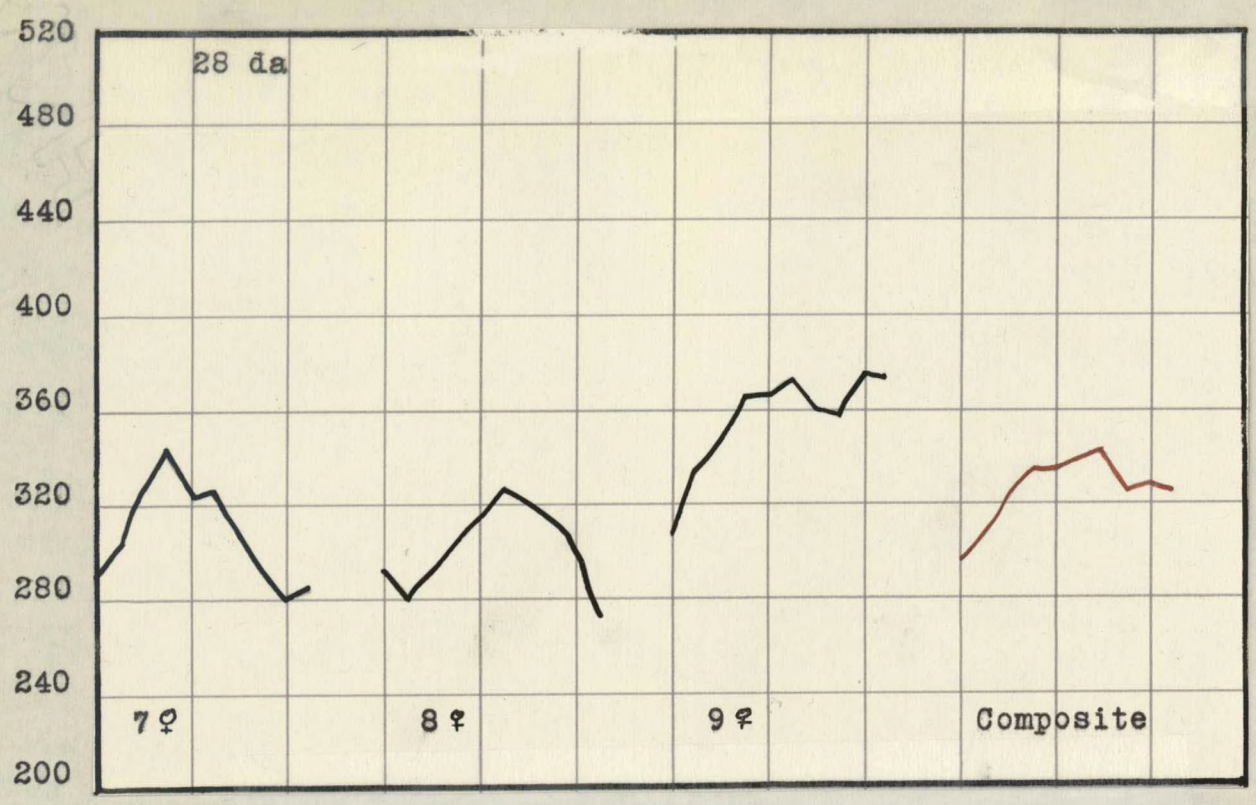
Growth Curves of Guinea Pigs Fed on Scorbutic Basal Ration.



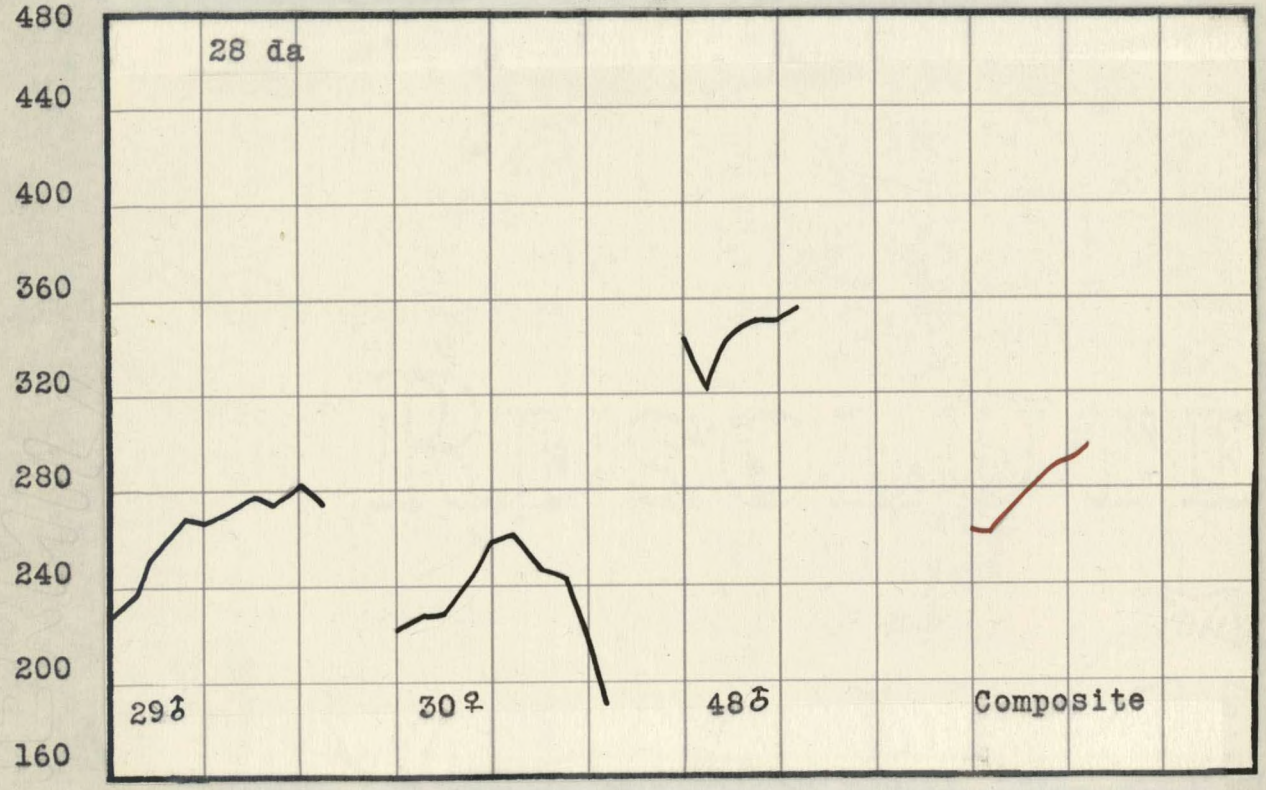
Series I, Group II.
Fig. III.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus Orange Juice.



Series II, Group X.
Fig. IV.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus Orange Juice.



Series I, Group III.
Fig. V.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus 2.5 gms. Raw Potato.



Series II, Group XI.
Fig. VI.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus 2.5 gms. Raw Potato.

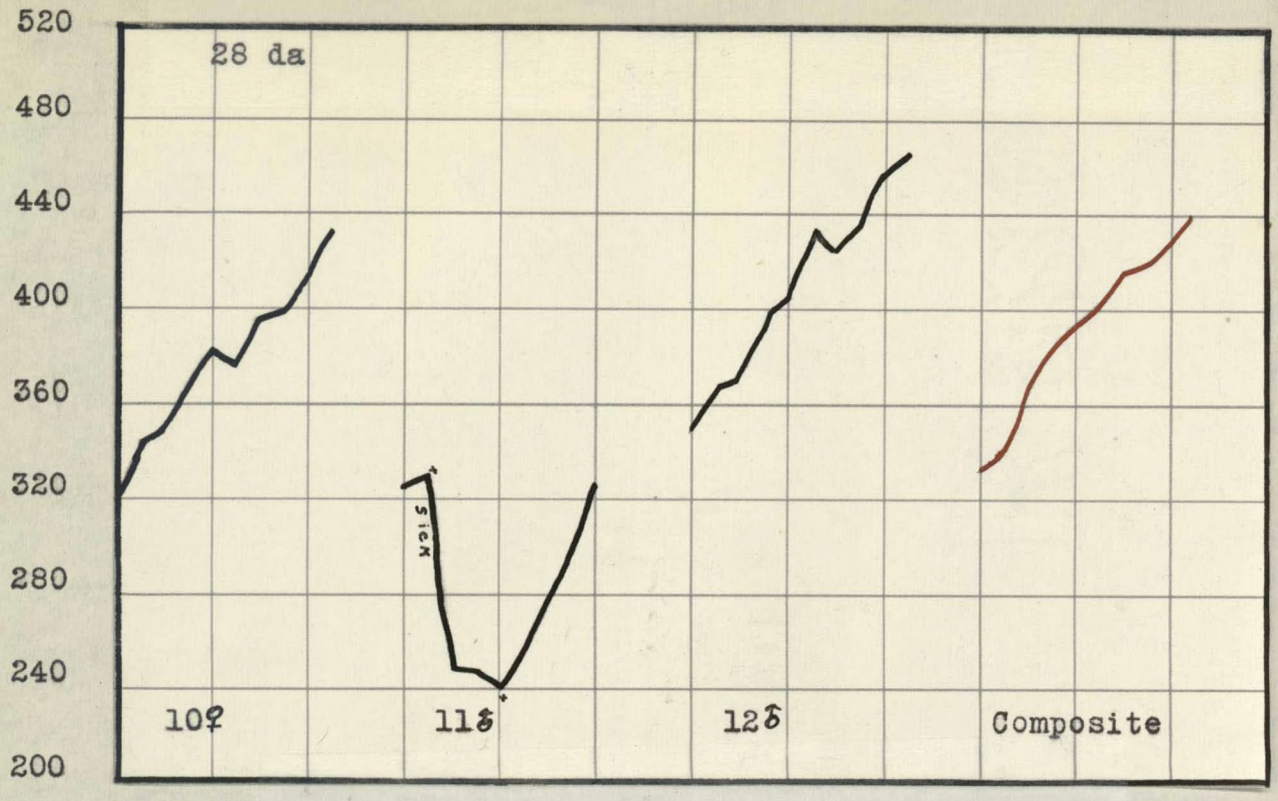
due to pneumonia and had nothing to do with the diet. (Fig. VII).

The group fed basal ration plus 10 grams raw potato daily was composed of a male and a female. The male, grew steadily at about the same rate as those animals fed on 5 grams raw potato, but the female, which was pregnant, lost weight rapidly after the fourth week. This drop in weight was caused by a loss of the fetus and upon autopsy at the end of the experiment there were no evidences of the animal having been pregnant. There were no other signs of abnormality and both animals seemed to be in good health.

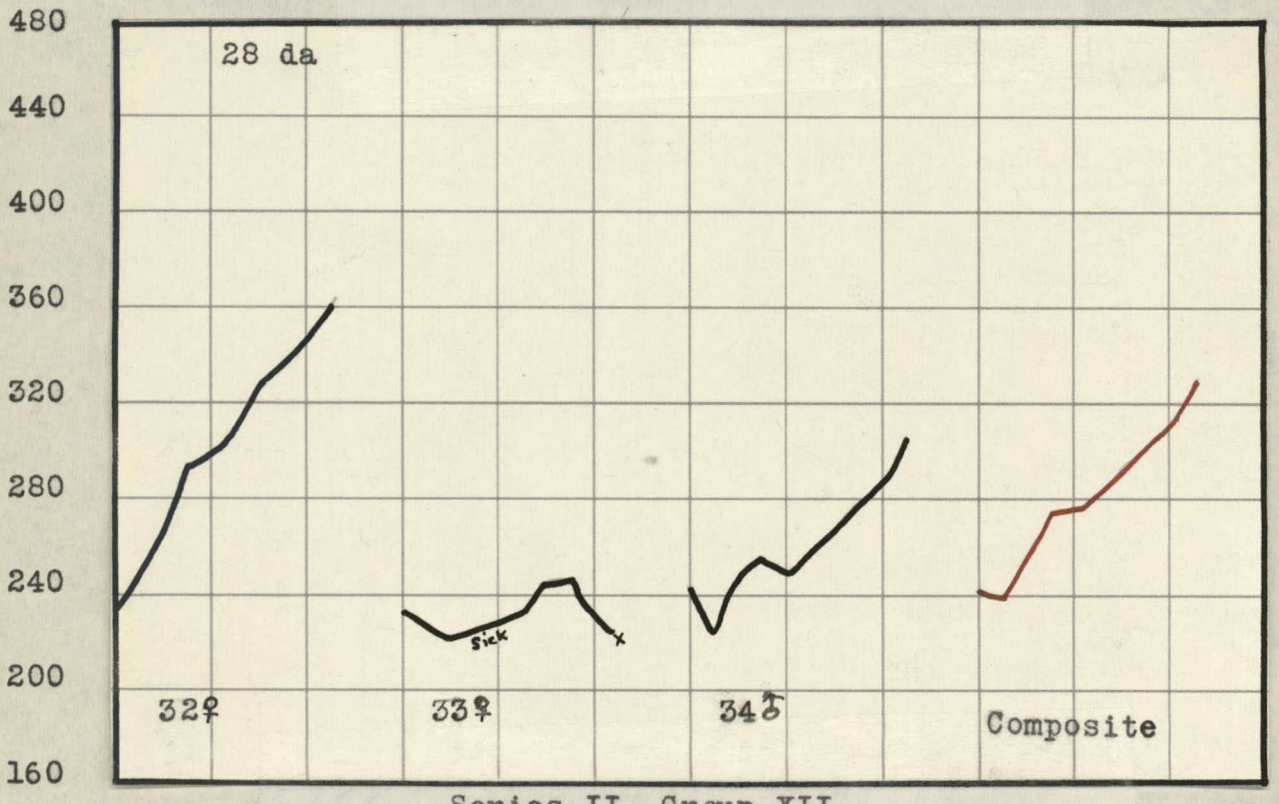
Only one animal was carried through the experimental period on 20 grams raw potato in addition to the basal ration since the others seemed unable to eat such a large amount of special food. During the time that the potato was consumed, the animal grew as well as those on 5 and 10 grams of potato, but at the end of the fifth week the appetite seemed to lag and the last two weeks, when the potato was almost entirely uneaten there was a marked drop in body weight of the animal. (Fig XI a).

The group which received 10 grams of cooked potato in addition to the basal ration showed a uniform dropping off in weight after the fourth week. This was similar to the effect obtained from the feeding of 2.5 grams of raw potato. No signs of scurvy were noted (Fig. XIII).

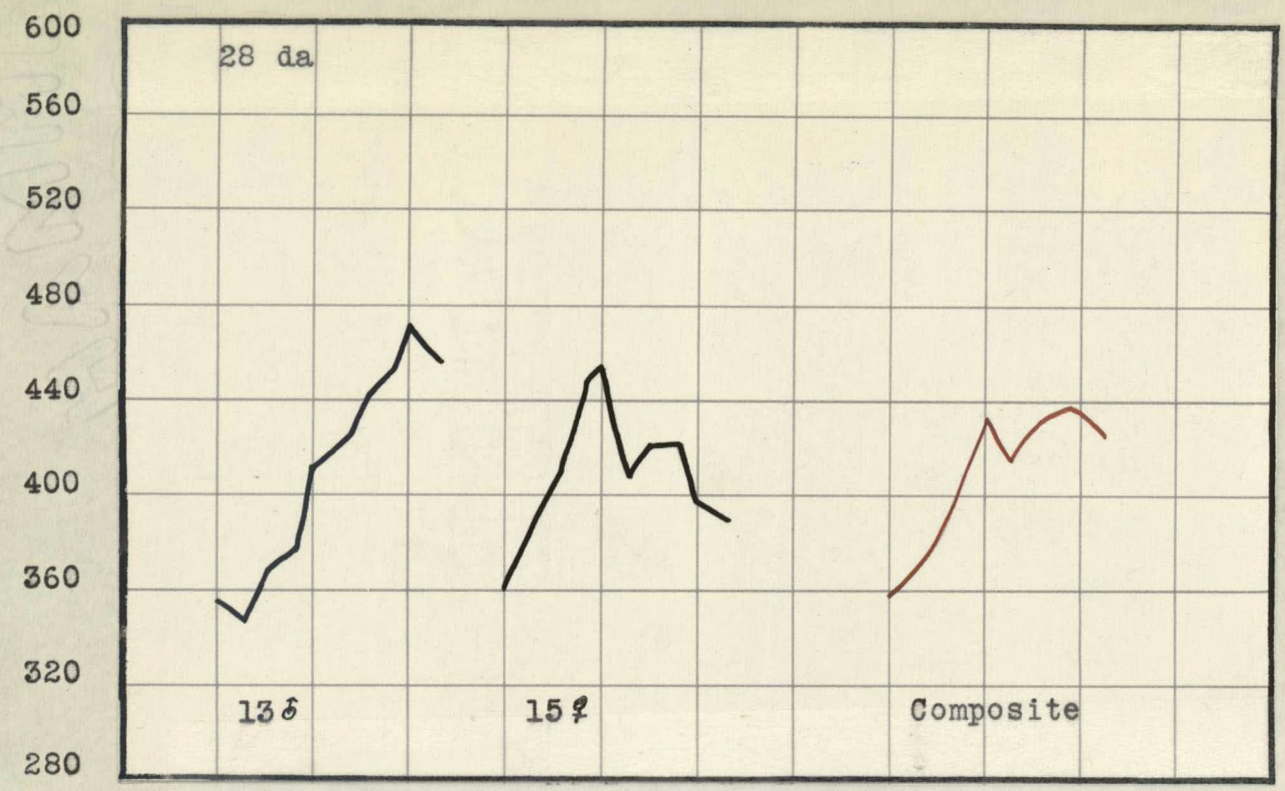
The one animal which was carried through the experimental period on 20 grams of cooked potato plus basal ration grew irregularly at first, but after the fifth week, its growth was similar th that obtained from 5 grams of raw potato. (Fig. XI b).



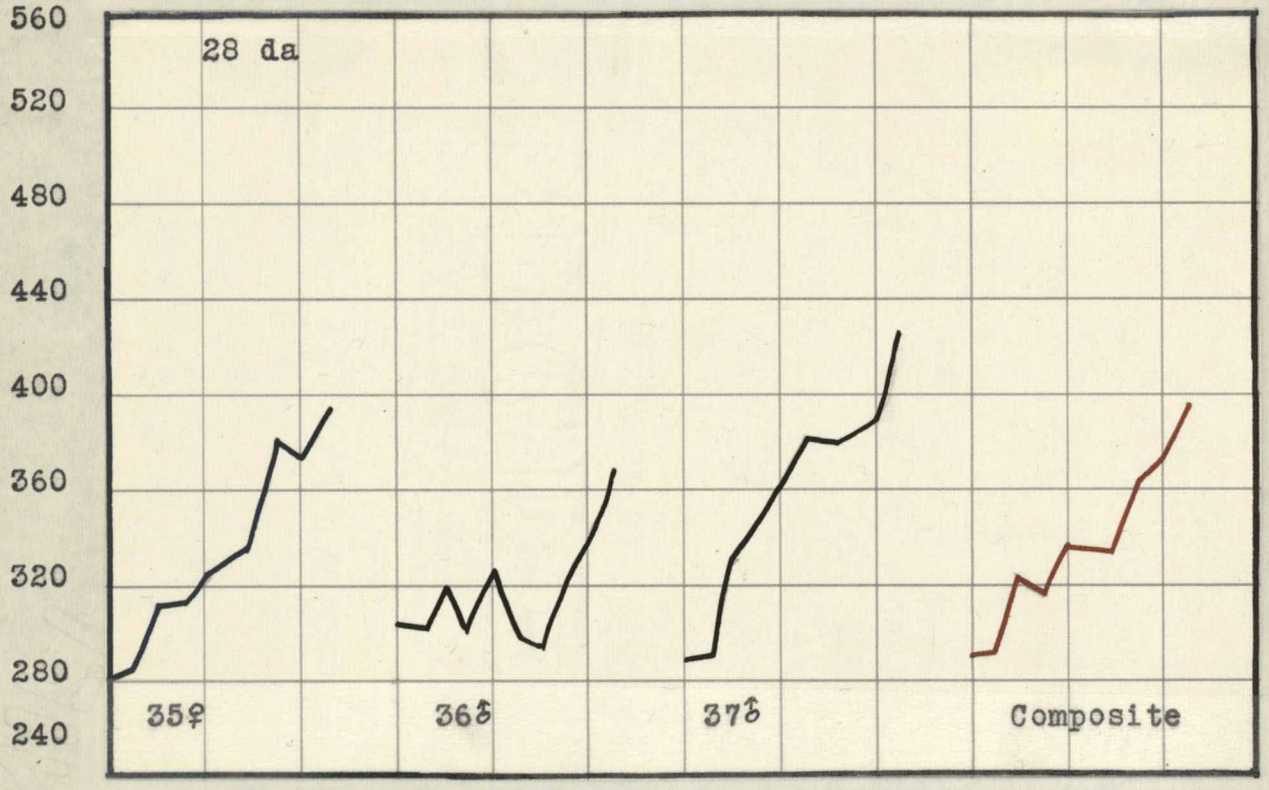
Series I, Group IV.
Fig. VII.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus 5 grams Raw Potato.



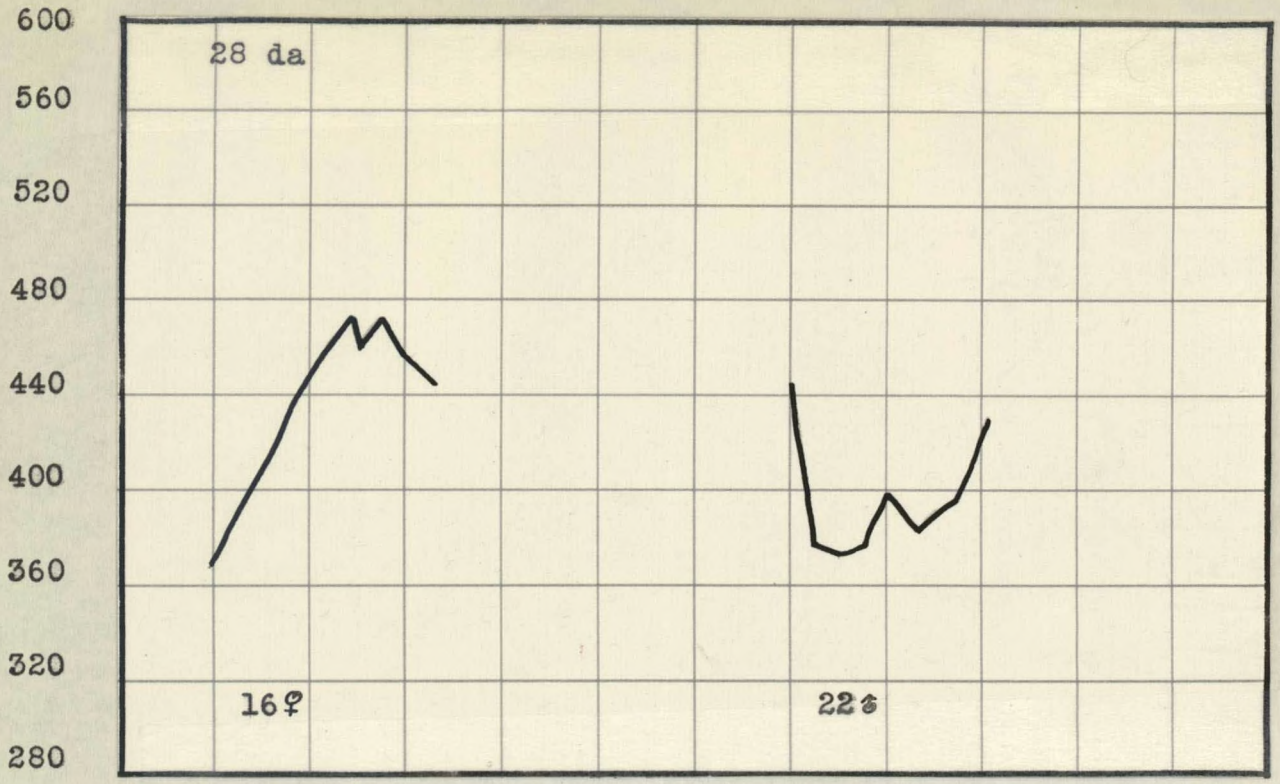
Series II, Group XII.
Fig. VIII.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus 5 grams Raw Potato.



Series I, Group V.
Fig. IX.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus 10 grams Raw Potato.



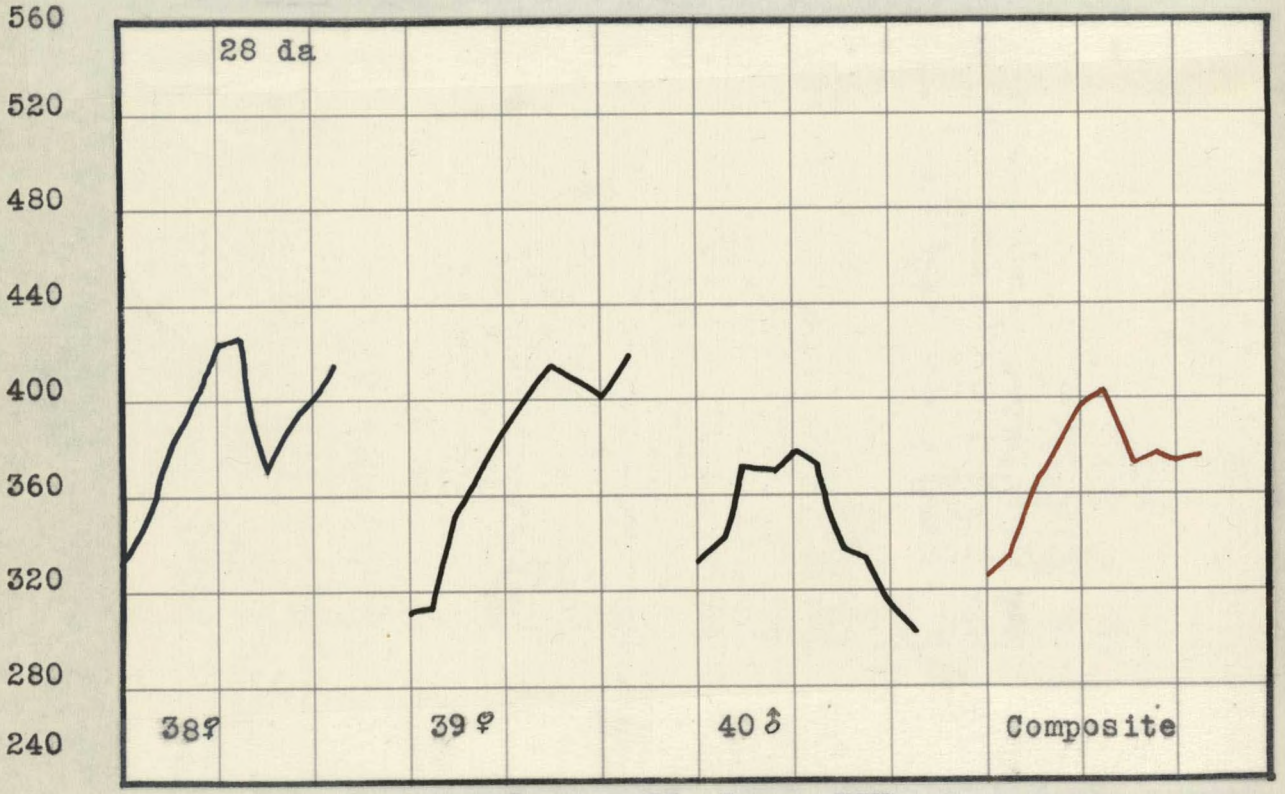
Series II, Group XIII.
Fig. X.
Growth Curves of Guinea Pigs Fed on Basal Ration plus 10 grams Raw Potato.



Series I.

Group XIa Group XIb.

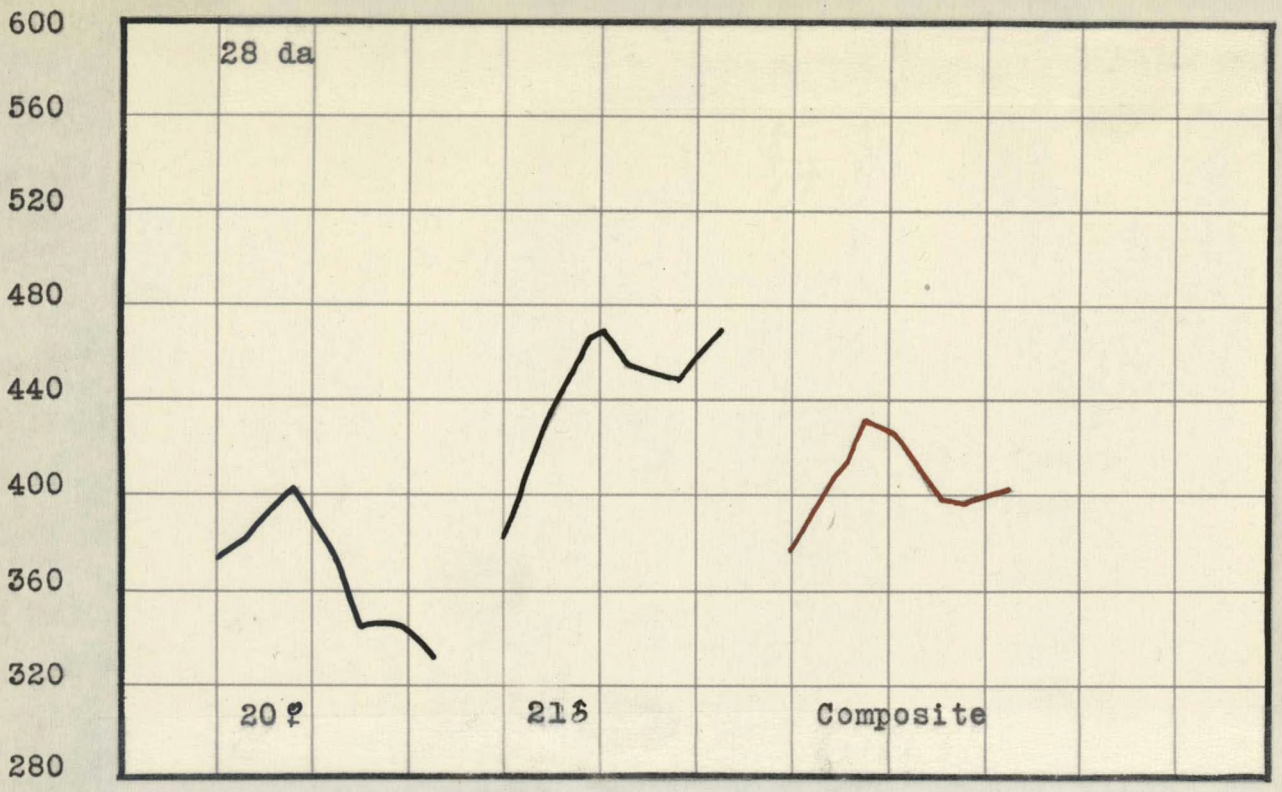
Growth Curves of Guinea Pigs Fed on Basal Ration Plus (a) 20 grams Raw Potato (b) 20 grams Cooked Potato.



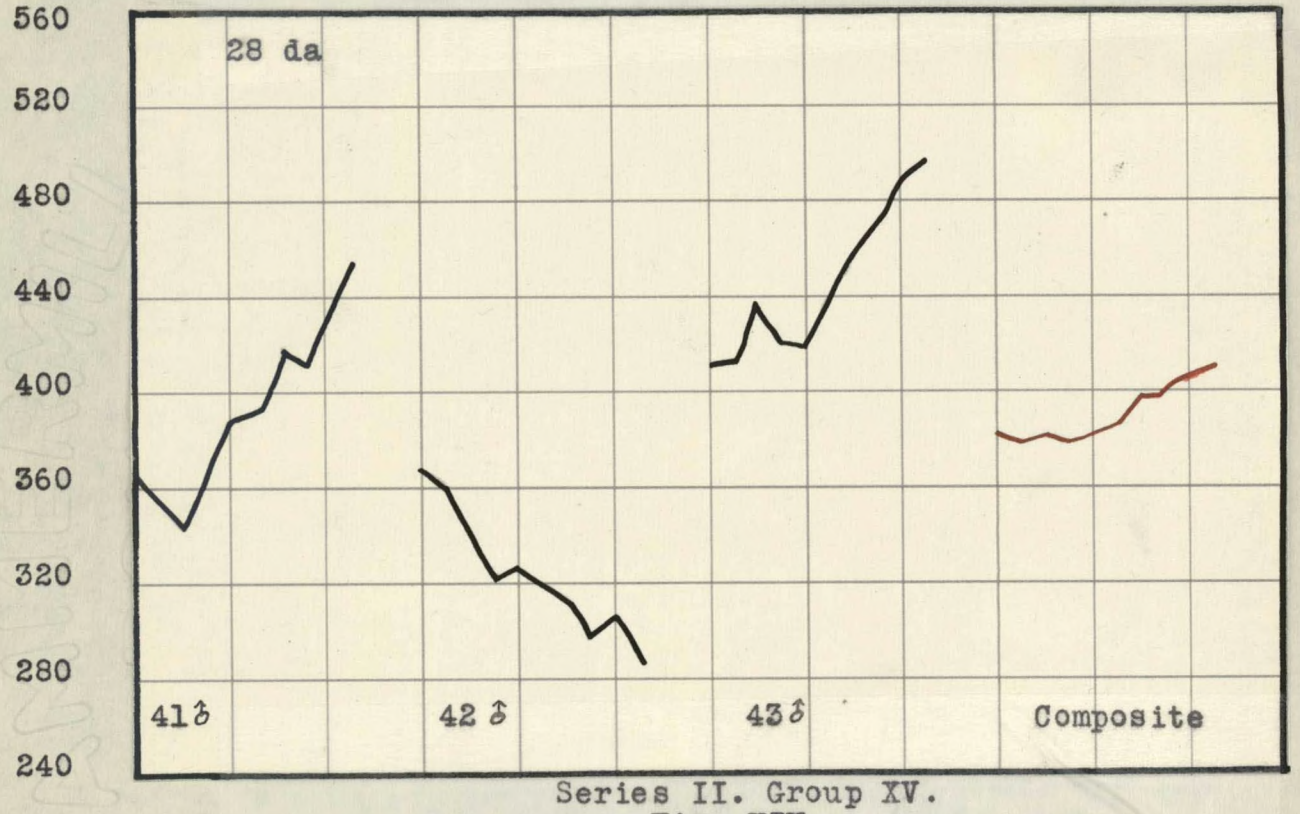
Series II, Group XIV.

Fig. XII.

Growth Curves of Guinea Pigs Fed on Basal Ration Plus 5 grams Cooked Potato.



Series I, Group VII.
Fig. XIII.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus 10 grams Cooked Potato.



Series II. Group XV.
Fig. XIV.
Growth Curves of Guinea Pigs Fed on Basal Ration Plus 10 grams Cooked Potato.

In the second series the control group fed on the scorbutic diet only showed very pronounced signs of scurvy. Some lost weight from the first others gained slightly the first two weeks and then declined in weight. Upon autopsy there were again found hemorrhages at the wrist and ankle joints and along the ribs, beading at the costo-chondrial junctions and enlargement of the adrenal glands. One guinea pig (26 ♀) lost less body weight than the others but developed the worst case of scurvy. For five days before death while still eating well, the animal was noticed lying in a "face-ache" position and whined when the wrist and ankle joints were pressed. On autopsy showed more pronounced evidences of scurvy than were seen in the others. (Fig. II).

The experience with the positive control group of the first series made it seem advisable to increase the amount of orange juice from 2 to 3 cc daily, for a similar group in the second series. As a result the rate of growth was very satisfactory (Fig. IV).

The group on basal ration plus 2.5 grams raw potato grew fairly well until the end of the third or fourth week when there was a general slowing up of the rate of growth and in one case a steady drop in body weight which continued until the end of the experimental period. Autopsy showed, in one guinea pig, a very pronounced hemorrhage on one of the hind legs, as severe as any noted thus far in the experiment. The only other evidences of a scorbutic condition were slight hemorrhages at wrist joints and emaciation of the body. Another animal in this group which had lost considerable body weight showed no signs of scurvy. (Fig. VI).

It was especially noted that the reproductive organs in the

group just described were underdeveloped to a marked degree and in some cases difficult to find.

The guinea pig which received 5 grams of raw potato daily in addition to the basal ration grew well with one exception. This animal did not eat well and seemed to have some digestive disturbances. The others which grew steadily were able to store considerable fat and gave no signs of any abnormalities. (Fig. VIII).

It may be said of the guinea pigs fed on 10 grams raw potato daily that they were healthy, were able to store fat normally and grew at approximately the same rate as those on 5 grams raw potato daily. (Fig. X).

The group receiving 5 grams cooked potato gave quite irregular results as to growth. One female (38 ♀) showed a sudden drop in body weight at the end of the fifth week, which was interpreted as indicating resorption. Autopsy, however, gave no signs of pregnancy. Another animal in this group grew moderately for four weeks, then decreased steadily in weight until the end of the period. There were no abnormalities noted when the animal was autopsied.

The third, in this group made good growth and in all respects was a normal healthy animal. (Fig. XII).

Two of the guinea-pigs kept on basal ration plus 10 grams of cooked potato gained moderately in body weight, ate well, stored fat and were healthy, while the third lost weight. Autopsy showed this animal very thin but otherwise normal. (Fig. XIV).

The feeding of 20 grams of both cooked and raw potato was omitted from this series since the animals seemed unable to consume that much special food daily.

DISCUSSION.

From the preceeding data, it will first be noted that the growth curves of the positive and negative control groups in each series are decidedly different. When the basal ration alone was used in every case there was a rapid decrease in weight, resulting in death at the end of 19 to 36 days, with definite signs of scurvy. The initial spurt of growth noted in the negative control group of the first series (Fig. I) might be accounted for by the fact that prior to the experimental period they had been fed more fresh food than those of the second series (Fig. II) and therefore might have had a larger supply of nutritive factors stored in their tissues.

With the positive control groups of both series a little difficulty was experienced in determining the exact amount of orange juice required to protect the animals from scurvy and permit growth at a moderate rate. Previous investigators (6) (7) reported using 1.5 cc and 2 cc. orange juice as a minimum protective dose. Consequently at the beginning of the first series (Fig. III), 2 cc of orange juice were given daily. This amount was found to be somewhat inadequate in most cases. When near the end of the experiment the amount was doubled, there was a very noticeable increase in the rate of growth. This led to the use of an intermediate amount in the positive control group of the second series, (Fig. IV) - 3 cc of orange juice daily. With this amount there was a steady increase in body weight of the animals.

With the use of varying amounts of potato as a source of Vitamin C, a variety of growth curves were obtained ranging between those of the positive and negative control groups.

When 2.5 grams of raw potato were fed daily the individual growth curves as well as the composite curves in both series (Figs. V, VI) showed a rather uniform decrease in rate of growth at the end of the third week and a tendency toward steady decline in weight after that time. In a few cases there were slight evidences of a scorbutic condition.

In comparing these results with those of the negative control groups it can be seen that 2.5 grams of raw potato afford a slight protection in that the time of weight decline was deferred a week or two and scorbutic symptoms were much less noticeable. Therefore, 2.5 grams of raw potato are not quite sufficient to serve as a minimum protective dose against scurvy in guinea pigs.

When 5 grams of raw potato were fed daily the general rate of growth in series I (Fig. VII) seemed very similar to that of the positive control group fed on orange juice. In series II (Fig. VIII) only one animal showed as good growth as those of series I, however, the failure of 33 ♀ to grow at a normal rate, might be attributed to some very definite signs of intestinal disturbance. When the composite curves of Groups IV and XII are compared, there will be noticed only a slight flattening of that of Group XII. Without additional data this might indicate very slight deterioration of the potency of vitamin C during the six months of winter storage.

When the growth curves of the two groups (Group V and XIII) fed on 10 grams of raw potato are examined one observes that the general line of the curves differs very little from the control group fed on orange juice and the group receiving 5 grams of raw potato daily. However, it should be especially noted that portions of these fluctuating curves rise at a steeper angle than is found in preceding

curves. From data summarized in Tables II and III, calculations show that the percentage gain in body weight per gram of potato eaten averaged .042 for 10 grams of raw potato and .092 for 5 grams of raw potato. This seems to indicate that 5 grams of raw potato daily supplies a guinea pig the optimum amount of vitamin C, but that when 10 grams of raw potato are consumed, a proportional rate of growth does not result. There is a possibility that a portion of the larger amount of vitamin C may not be utilized. In comparing the two series where the guinea pigs were fed 10 grams of raw potato, those of the second series grew as well, if not slightly better than the animals of the first series. From this there is no evidence of any deterioration of vitamin C during the six months storage of the potatoes.

Only one member of Group XIa was carried through the experimental period on a diet of basal ration plus 20 grams of raw potato daily, since the others were unable to consume that amount of special food. Again, the growth curve of this one animal closely resembled those of the guinea pigs fed on orange juice and 5 grams raw potato. This reemphasizes the indication noted above that a portion of the larger amount of vitamin C may not be utilized by the animal.

No study of the vitamin content of potato would be complete without some data on the cooked product since it is in this form that the vegetable is used. According to Sherman's (1) table the cooking of the potato reduces the potency of its vitamin C to about one-fourth of its original value. Hence, it seemed advisable to start with 10 grams cooked potato as a supplement to the basal ration. Group VII fed in this way shows growth curves not unlike those of Group III fed on 2.5 grams of raw potato. This would seem to agree

TABLE II, Comparative data from Series I showing the percentage of gain in weight per gram of food eaten.

No.	Initial wt. in grams	Final wt.in grams	Gain in wt. in grams	Total gms. Basal ration	Total grams raw potato	Total grams cooked potato	Total grams orange juice	Total grams food eaten	Gain in wt.per gram of food.	% gain in wt. per gm of food	% gain in wt. per gm potato	% gain in wt. per gm. orange juice
1 ♀	340.4	209.1	131.3	259				259	-.5	-.15		
2 ♂	343.4	297.5	-45.9	221				221	-.2	-.058		
3 ♀	341.1	207.8	-133.4	245				245	-.5	-.14		
4 ♀	287.3	333.0	45.7	695			157	847	.054	.018		.11
5 ♂	286.9	433.8	146.5	881			157	1033	.14	.05		.33
6 ♀	291.6	352.0	60.4	819			157	971	.062	.021		.137
7 ♀	290.3	284.8	-5.5	614	160			774	-.0065	-.0022	-.01	
8 ♀	294.3	273.5	-20.8	579	160			739	-.028	-.009	-.044	
9 ♀	307.8	362.1	54.3	776	160			936	.058	.018	.11	
10 ♀	315.5	433.8	118.3	749	320			1069	.11	.034	.117	
12 ♂	349.9	466.0	136.1	949	320			1269	.107	.03	.12	
13 ♂	356.3	456.1	99.8	852	650			1482	.07	.019	.042	
15 ♀	362.3	391.8	29.5	695	600			1295	.022	.006	.013	
16 ♀	366.6	447.3	80.7	738	1160			1898	.042	.011	.02	
18 ♂	369.4	413.0	42.6	560		1160		1720	.025	.006	.009	
20 ♀	415.5	373.0	42.5	583		640		1223	.035	.008	.013	
21 ♂	422.1	510.2	88.1	722		600		1322	.066	.013	.033	
22 ♀	449.1	441.0	8.1	623		1160		1783	-.004	-.0008	.0015	

TABLE III. Comparative data from Series II showing the percentage of gain in weight per gram of food eaten.

No.	Initial wt. in grams.	Final wt. in grams.	Gain in wt. in grams	Total gms. Basal ration	Total grams raw potato	Total grams cooked potato	Total grams orange juice	Total grams food eaten	Gain in wt. per gram of food.	% gain in wt. per gm of food	% gain in wt. per gm potato	% gain in wt. per gm orange juice
24 ♀	194.8	329.6	134.8	800			189	989	.135	.069		.36
44 ♂	319.0											
45 ♂	470.6											
26 ♀	279.5	267.2	-12.3	326				326	-.04	-.014		
27 ♂	271.0	229.3	-41.7	233				233	-.18	-.066		
28 ♀	276.7	194.0	-82.7	142				142	-.3	-.13		
46 ♂	341.7	220.5	-121.2	266				266	-.45	-.109		
47 ♂	478.0	295.0	-183.0	280				280	-.65	-.13		
29 ♂	226.5	273.1	46.6	760	180			940	.05	.022	.11	
30 ♀	222.7	191.3	-31.4	792	180			970	-.032	-.014	.08	
48 ♂	346.1											
32 ♀	236.3	361.1	124.8	780	360			1140	.108	.046	.128	
33 ♀	231.4	211.8	19.6	608	340			948	.02	.009	.024	
34 ♂	243.9	307.7	63.8	649	360			1009	.063	.026	.072	
35 ♀	285.1	394.2	109.1	781	700			1481	.013	.005	.055	
36 ♂	305.0	372.1	67.1	720	710			1430	.046	.014	.03	
37 ♂	290.4	426.0	135.6	756	710			1466	.09	.031	.07	
38 ♀	331.8	414.0	82.8	913		360		1273	.065	.02	.066	
39 ♀	312.7	420.2	107.5	880		360		1240	.087	.027	.096	
40 ♂	334.0	302.5	31.5	882		360		1242	.025	.007	.029	
41 ♂	367.2	454.6	87.4	791		720		1511	.057	.015	.032	
42 ♂	367.0	289.4	77.6	628		720		1348	-.058	-.016	-.03	
43 ♂	412.5	492.7	80.2	988		720		1708	.047	.012	.026	

with Sherman (1) in his conclusions regarding the effect of cooking.

Later when Group XV in Series II was fed on the same type of ration the animals, with one exception (42) furnished growth curves which showed a decided improvement over those of Group VII, in fact they nearly approached the angle of the growth curves of Group XIII fed on 10 grams of raw potato. This improvement in rate of growth cannot be explained on the grounds of increase of vitamin C in the potato kept in storage, for the potatoes used in this experiment were the same as those studied in the raw condition where little if any improvement in growth rate was noted. Neither can it be explained by the fact that during storage, shrivelling occurs which increases the percentage of solid nutrients in the potato, as this would also have been noted in the experiments with raw potato. Since none of the investigators have mentioned similar results it can only be justified by the assumption that during storage some change takes place which causes the cooked potato to be more completely utilized thereby improving the rate of growth.

The above assumption is further supported by the results obtained with 5 grams cooked potato which were used in an experiment in the second series only. The members of Group XIV grew nearly as well as those of Group XII of the second series which received 5 grams raw potato. Since all of the potatoes used in the second series had been stored for an equal length of time under the same conditions it must be assumed that some change has occurred in the stored potato so that upon cooking no deterioration in food value is observed.

In fact so little study has been made of the effect of storage upon the food nutrients of vegetables that at the present time one can do little more than present a theoretical explanation for some of the changes which appear to take place.

SUMMARY.

1. 2.5 grams of raw potato daily did not give guinea pigs adequate protection against scurvy.
2. 5 grams of raw potato daily were equivalent to 3 cc of orange juice in their antiscorbutic value.
3. 10 and 20 grams of raw potato daily appeared to be similar to 5 grams of raw potato in their antiscorbutic value and support of growth.
4. There is some evidence that only a certain amount of vitamin C in potato is utilized by the guinea pig.
5. After six months storage under excellent conditions there appeared to be no loss of vitamin C in potatoes.
6. The cooking of potatoes in the early period of storage reduced the potency of vitamin C to one-fourth its original value.
7. After six months storage there were indications that some change had occurred in the potato so that the cooked product seemed to have almost as beneficial an effect upon the growth of guinea pigs as the raw stored potato.

CONCLUSION.

When potatoes raised in Gallatin Valley were stored during the winter of 1926-1927 under the following conditions; average relative humidity, 95%; average temperature, 3.5°C; and good ventilation, there was no deterioration in their vitamin C content.

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