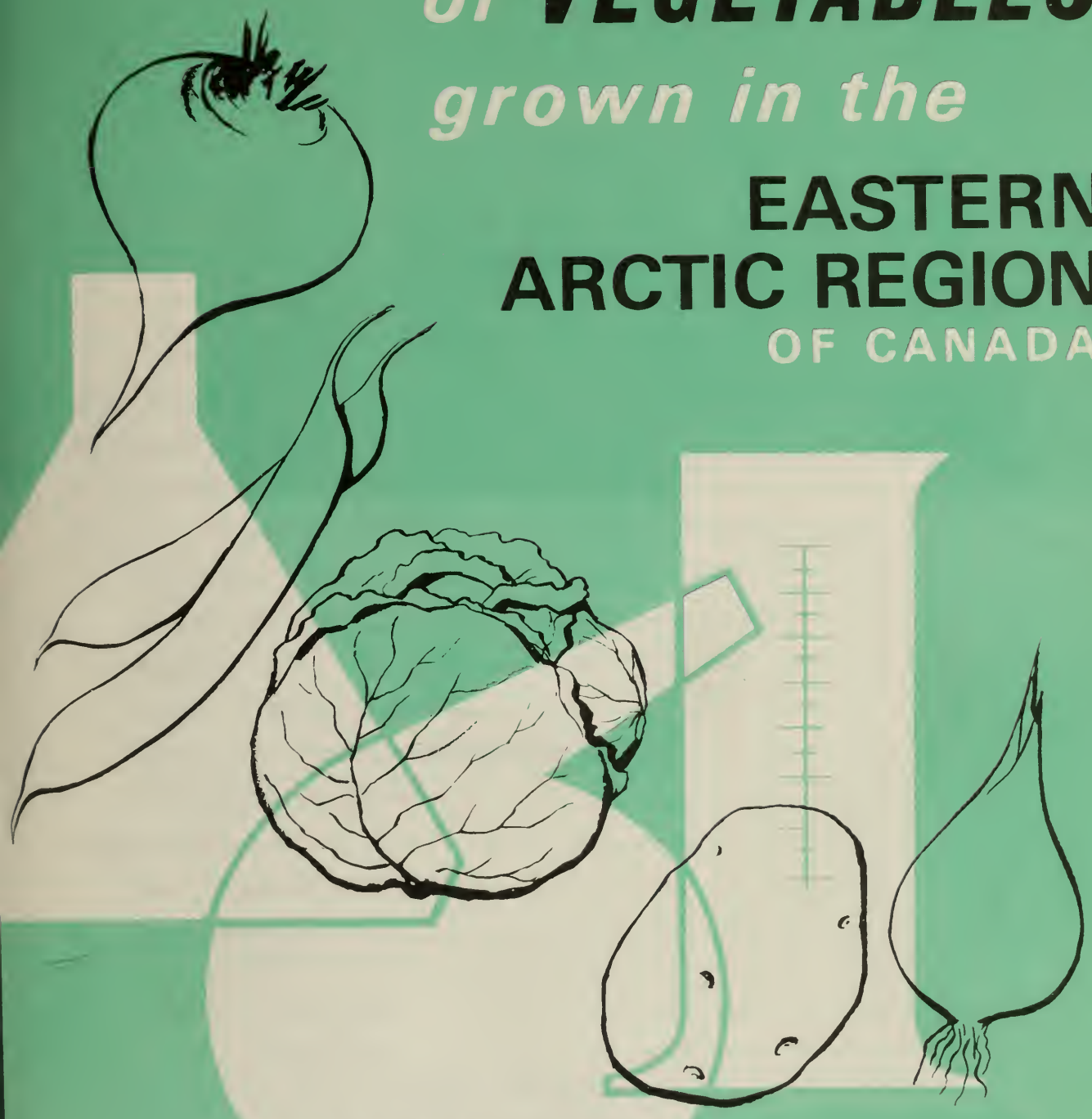
an evaluation of VEGETABLES grown in the EASTERN ARCTIC REGION OF CANADA



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AN EVALUATION OF VEGETABLES GROWN IN THE EASTERN ARCTIC REGION OF CANADA

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INTRODUCTION

The provision of adequate supplies of nutritious food to satisfy the physiological requirements of adults and children is one of the basic factors limiting the development of the North. The rigorous climate of this vast area makes heavy demands on the human body. These demands must be adequately met with food rich in carbohydrates, proteins, minerals and vitamins.

In order to avoid heavy food shipments into these remote areas, it would be particularly beneficial if the Northland could be made nutritionally more self-sufficient. Local production of fresh vegetables would obviate the deterioration and spoilage of produce during transit as well as the high cost of transportation. In addition, the general morale of the residents would be raised by the sense of accomplishment, independence and self-sufficiency derived from this new occupation.

The project described in this publication was undertaken to produce leaf and root vegetables and to determine by chemical analysis their ascorbic acid (vitamin C) and carotene (provitamin A) contents. A search was made for hardy, rapid-growing, early maturing and cold-resistant varieties of vegetables that might be adaptable to subarctic conditions. Parallel investigations were directed towards the development of agricultural practices that would effectively shorten the growing period.

REVIEW OF LITERATURE

The potential for developing agriculture in Northern Canada has received the attention of several authors (6, 7, 8, 12, 13, 14, 16), all of whom have emphasized that the production of certain vegetables is entirely possible even on ground underlain by permafrost. Though levels of productions have been reported for a number of crops grown in arctic and subarctic regions of Canada (15), nutritional levels have not been determined until recently.

Reports by Danishevskii (5) and Chekin (4) indicate that in some cases vegetables grown in Russian polar regions are rich in vitamins. However, Ivanovskii (9) has concluded that, in general, although the ascorbic acid content of vegetables varies with weather conditions, soil fertility, plant variety and cultivation practices, it differs only a little from the content of vegetables grown in temperate zones. He has postulated that the longer wavelengths characteristic of sunlight in high northern latitudes as well as the clarity of the air and the longer hours of daylight tend to enhance vitamin formation through an increase in the intensity of photosynthesis. However, this is counterbalanced by the handicap of lower soil temperatures and the scarcity of useful soil microorganisms, particularly those responsible for nitrification.

SITE OF PROJECT

The work reported here was performed in 1964 and 1965 at the Canada Department of Agriculture Research Substation, Fort Chimo, Quebec, in the Ungava Bay area. The exact site was at 58°07' north latitude and 68°09' west longitude, which is near the junction of Upper False River and Kohlmeister Lake. The substation is approximately 900 air miles from Montreal, Quebec, and the basic air cargo freight rate during the years of study was 29 cents per pound. All equipment and supplies were airlifted to Fort Chimo, Quebec, and transshipped to the station. Ocean freight from Montreal to nearby Fort Chimo took 10 to 14 days and cost $55 per ton.

The laboratory was located in a corrugated metal quonset hut supplied with 60-cycle power (Delco) and furnished with plywood working benches. The interior walls were covered with Ten Test, and a stainless steel sink and a drying rack were installed.

As an aid to research workers who may be faced with the problem of setting up an analytical laboratory in a remote area, full details of the equipment required to operate the laboratory are given in Appendix 1.

METHODS OF GROWING CROPS

At the Fort Chimo station snow disappears from the ground about June 10. Ten days later, vegetables that have been started in the greenhouse can be transplanted. Direct seeding outdoors can be started by July 6. The growing season lasts till about September 18.

The basic fertilizer applied in the spring to soil in greenhouses and to fields was 400 lb of 10-30-10 per acre. Any other fertilizers used were in addition to this basic application.

Aerial view of the research station at Fort Chimo, Quebec.

Research Station, Fort Chimo, Quebec.

Greenhouse Preparation

Soil placed in the greenhouses the previous fall was spaded in April and the basic fertilizer was worked in. Soil was sieved and placed in wooden flats. Seeds were planted, water was applied generously and the flats were covered with plastic sheets to help germination. When the seedlings emerged, the plastic was removed. After 3 weeks the most vigorous seedlings were selected and transplanted to 3-inch peat pots. Before being placed in the field, the plants were hardened by leaving them outdoors for progressively longer periods of time each day for several days.

Field Preparation

When the ground had thawed it was worked over with a small garden tractor and the basic fertilizer was applied with a hand-operated fertilizer spreader (Gandy). In some cases strips of clear polythene, 2 mil thick and 42 inches wide, were spread over the ground and secured along the edges and at the corners with stones. The plastic served as a mulch to raise soil temperatures and to retard loss of moisture. When the hardened plants were ready for the field, slits were cut in the plastic and the pots containing the plants were put in place. During the 1964 season, plants were replicated and the replicates were broken down into blocks or sub-plots, which were given different fertilizer treatments. In 1965, varieties of crops were replicated but all were given the same fertilizer treatments except for those under clear plastic mulch, which received different fertilizers in some rows. Growth proceeded under natural conditions during the growing season.

Mulches

In addition to clear plastic sheeting, different liquid mulches were used in the growing trials. One week after the seeds were planted a good covering of the liquid mulch was applied. A second application was made 3 weeks later. Details of the mulches used are given in Table 1.

Outdoor Planting of Seeds

All varieties of vegetables were planted by hand in 10- to 12-foot rows. Basic fertilizer only was used for all seeded vegetables, and mulch was used only for spinach, leaf lettuce and Swiss chard, which were grown under clear plastic, in 1964. Slits were cut in the plastic after the seeds germinated.

After emergence and germination, the rows were thinned out according to good agricultural practice. On reaching maturity, radishes, onions, Swiss chard, spinach, leaf lettuce and turnips were harvested and analyzed. Vegetables that did not reach maturity were not harvested, but growth progress (plant height and leaf spread) was recorded.

Table 1 Source and formulation of mulches used in growing vegetables at Fort Chimo, Quebec, 1964 and 1965

Field treatment number	Trade name of mulch	Source	Formulation sprayed
T1	Esso asphalt	Imperial Esso Marketing Department 111 St. Clair Avenue, W. Toronto 7, Ontario	as received
T2	Ethofat 242/25	Armour Industrial Chemicals Company 100 University Avenue Toronto 1, Ontario	1 oz/gal water
T3	Aqua Gro	Aquatrols Corporation of America 730 Lancaster Avenue Bryn Mawr, Pa. 19010, U.S.A.	1 oz/gal water
T4	O.E.D. (oxyethelene docosanol)	Nikken Chemicals Company, Ltd. Japan	12 g/liter water
T5	D.D.A.C. (dimethyloctadecyl ammonium chloride)	Armour Industrial Chemicals Company 100 University Avenue Toronto 1, Ontario	10 g/liter water
T6	Clear plastic (2-mil poly film)	Canadian Industries Ltd. P.O. Box 10 Montreal, Quebec	
T7	Check (no mulch)		

Greenhouse Planting of Seeded Plants

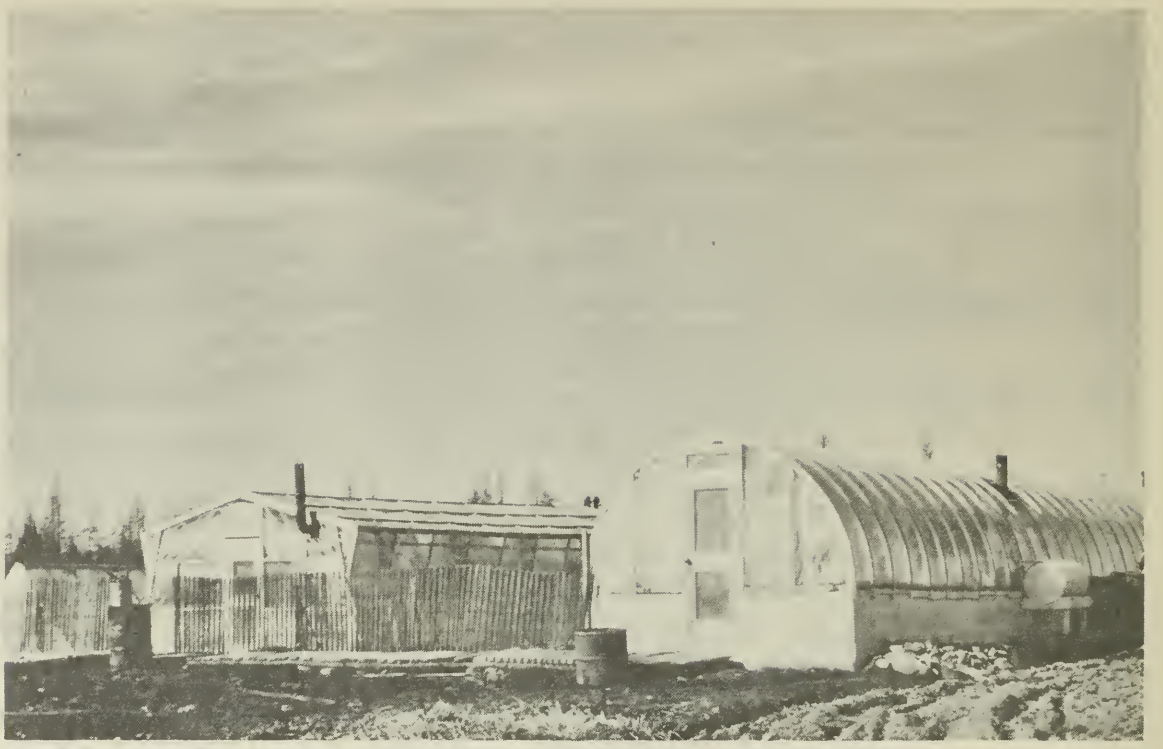
When outdoor transplanting was not needed, seeds were planted in rows and allowed to germinate. The seedlings were thinned according to good agricultural practice. In some cases, transplants were placed in the greenhouse soil and allowed to reach maturity. Plants were watered, as required, in the early morning and late afternoon. Flowering vegetables that required pollination were treated with hormone spray (Seedless Set). When mature, vegetables were harvested and analyzed.

Description of Greenhouses

The following information gives greenhouse reference number (for example, GH 1), type of construction and covering material, and the location of soil or plants.

GH 1 – Quonset type, permanent construction, 12-mil Amerex on outside, 3-mil mylar on inside. The soil in this particular greenhouse was held on raised benches.

GH 2 – Rigid frame, permanent construction, 5-mil mylar on outside, 3-mil mylar on inside. Plants were grown in the ground.



Greenhouses 2 and 1.

Greenhouses 4, 2 and 3. The laboratory is in the right background.

GH 3 – A-type, panel construction, 5-mil Amerex only. Plants were grown in the ground.

GH 4 – Modified A-type, panel construction, 5-mil mylar only. Plants were grown in the ground.

A coldframe (referred to as CF) had sloping walls of ¾-inch plywood with 5-mil Amerex panels resting on top.

SOIL AND CLIMATE

Soil Treatment and Analysis

Before the 1965 growing season all the soils in the greenhouses and fields were limed at the rate of 1.5 tons of $CaCO_3$ per acre and 1 ton per acre, respectively. Standard methods (1) were used in the Ottawa laboratories to analyze soil samples taken in 1964 and in 1965 (Table 2). The 1965 samples were taken after liming and the addition of fertilizer. Mechanical analysis (10, 18) were performed on four soil samples taken in 1964 (Table 3).

Meteorological Data

During growing seasons the prevailing winds are westerly, but strong northeasterly winds sometimes accompany a storm. Lajoie (11) reports that the cooling effect of tidal water is very marked at the Fort Chimo station. When the river, with a temperature of about 68 F, meets the huge mass of sea water (about 50 F), there results a local northern cool breeze, which is accompanied at times by slight fog.

Rainfall

Average rainfall figures for the Fort Chimo station during 1964 and 1965 are given in Table 4.

Soil Temperature

Ten thermocouples were permanently embedded at different depths under both the cultivated and uncultivated areas and readings were taken every two weeks with a telethermometer. Table 5 shows average soil temperatures for the period June 8 to September 24, 1965.

As might be expected in soils underlain by permafrost, temperatures tended to decrease with depth. Temperatures near the surface were higher in

Table 2 Chemical analysis of soil samples from the Department of Agriculture Research Substation, Fort Chimo, Quebec, 1964 and 1965

Identification	pH in water	Organic matter	Total nitrogen	Phosphorus[1]	Potassium[2]	Acetate-exchangeable cations[3]							Neutral salt-exchangeable cations[4]				
						Calcium + magnesium	Calcium	Potassium	Sodium	Sum of cations	Exchange capacity	Base saturation	pH in $CaCl_2$	Calcium + magnesium	Aluminum	Exchange capacity	Base saturation
		%	%	ppm	ppm	meq per 100 g soil						%	meq per 100 g soil				%
1964																	
No. 1 GH[5]	4.5	6.26	0.23	148.08	90	7.5	4.1	1.0	0.7	9.2	17.8	51	3.77	5.2	0.6	5.8	90
No. 2 GH (northwest side)	4.5	4.59	0.17	128.78	186	6.6	3.7	1.6	0.9	9.1	12.6	75	4.25	5.0	0.5	5.5	90
No. 2 GH	4.2	6.03	0.19	57.38	51	6.8	3.5	0.8	0.6	8.2	18.1	45	3.71	6.2	1.5	7.7	80
No. 3 GH	4.3	6.52	0.20	40.80	20	7.4	4.0	0.6	0.3	8.3	26.2	32	3.76	7.4	1.3	8.7	82
No. 4 GH	4.2	6.43	0.19	72.68	60	6.7	3.3	0.9	0.4	8.0	25.9	31	3.79	7.3	1.1	8.4	87
No. 1 field potato and vegetable test	5.6	7.29	0.28	9.95	31	14.1	9.3	0.6	0.7	15.4	21.1	73	5.30	13.1	--	13.1	100
No. 1 field cereal test	6.4	4.78	0.19	16.32	16	10.5	6.7	0.6	0.4	11.5	15.0	77	5.88	9.3	--	9.3	100
No. 3 field vegetable mulch	4.7	6.70	0.23	28.05	20	5.9	2.8	0.6	0.3	6.8	23.2	29	4.09	7.0	1.2	8.2	85
No. 3 field vegetable mulch	4.8	5.52	0.20	9.18	16	5.7	2.7	0.5	0.3	6.5	20.6	32	4.27	6.4	0.8	7.2	89
No. 4 field	5.2	4.10	0.16	0.06	12	5.4	2.6	0.4	1.7	6.5	13.2	49	4.92	5.5	0.4	5.9	93
No. 6 field	4.9	4.24	0.17	0.18	20	4.4	2.2	0.6	0.2	5.2	16.4	32	4.29	4.8	0.6	5.4	89
No. 7 field	5.2	3.34	0.12	0.12	33	3.1	1.8	0.5	0.8	4.4	13.6	32	4.55	4.1	0.4	4.5	90
1965																	
No. 1 GH	6.6	4.83	0.20	169.68	--	8.0	4.2	0.8	0.7	9.5	18.2	51	6.80	15.9	--	15.9	100
No. 2 GH	5.3	3.31	0.19	117.34	--	6.0	2.8	0.5	0.5	7.0	19.6	36	5. 2	12.9	9.5	12.9	100
No. 4 GH	6.5	3.86	0.21	111.10	--	11.3	5.3	0.7	0.3	12.3	27.3	45	6.7	25.1	16.7	25.1	100
No. 1 field vegetable test (limed section)	7.4	6.90	0.21	32.78	--	10.2	5.7	0.4	0.4	11.0	18.8	58	7.0	17.7	13.3	17.7	100
No. 1 field vegetable test (unlimed section)	6.1	6.45	0.25	35.98	--	7.7	5.2	0.5	0.6	8.8	20.1	44	5.6	16.7	13.6	16.7	100

[1] Olsen bicarbonate-extractable
[2] Water soluble
[3] In NH_4OAc at pH 7 for cations, in CaOAc + $CaCl_2$ pH 7 for capacity
[4] 0.01 *M* $CaCl_2$, absorbed cations replaced with 2 *N* NaCl
[5] GH = Greenhouse as described in text
-- means no analysis

Table 3 Mechanical analysis of soils[1] at Fort Chimo, Quebec, 1964

Identification	Sand		Total silt + clay	Total dry wt	Total clay	Clay size 2-1 μ		Clay size <1 μ	
	(g)	(%)	(g)	(g)	(g)	(g)	(%)	(g)	(%)
No. 1 GH	9.37	54.2	7.93	17.30	1.72	0.56	3.2	1.16	6.7
No. 4 GH	3.87	24.4	11.96	15.83	2.48	0.76	4.8	1.62	10.2
No. 1 field (cereal test)	3.69	28.1	9.44	13.13	2.88	0.62	4.7	2.26	17.2
No. 6 field	2.01	11.4	15.61	17.62	3.66	0.98	5.6	2.68	15.2

[1] 20.0 g samples, air-dry basis.

Table 4 Average rainfall at Fort Chimo, Quebec, 1964 and 1965

Month	1964 Rainfall (inches)	1964 Rainfall (inches)
May	0.81	0.54
June	1.53	1.24
July	2.17	3.60
August	2.91	3.13
September	3.75	1.66
Total	11.17	10.17

Table 5 Average soil temperatures at Fort Chimo, Quebec, June 8 to September 24, 1965

Depth (inches)	Cultivated area		Uncultivated area (degrees F)
	Bare ground (degrees F)	Grass cover (degrees F)	
0.5	61.9		64.8
4.0	59.6		65.2
			37.8[1]
			43.1[2]
			41.1[3]
8.0	55.6	50.8	65.9
14.0	47.2	46.8	47.5
20.0	45.4	46.0	40.8
30.0	42.4	44.1	38.4
40.0			37.0

[1] Under moss located in shrub (Labrador tea)
[2] Under moss located in dwarf birch
[3] Under sphagnum moss, no shrubs

the uncultivated area than in the cultivated area, and, in addition, temperatures were slightly higher up to a depth of 8.0 inches. Below this depth, however, the temperature gradient was steeper in the uncultivated area than in the cultivated area.

Lowest temperatures were recorded for the three moss covers. In a review of the interactions of vegetation and soil frost, Benninghoff (3) stated that mosses have a low thermal conductivity, especially when dry, but that they also have a large capacity for absorbing and holding water. In daytime they tend to lose moisture rapidly, and, because of the comparatively high latent heat of vaporization of water, the adjacent soil is strongly cooled.

Air Temperature

Temperatures in greenhouses GH 1 and GH 2 were recorded on Tempscribe Bacharach circular chart thermographs. Maximum-minimum thermometers were used in greenhouses GH 3 and GH 4. An ordinary thermometer was used in the cold frame structure.

Average air temperatures are shown in Table 6. The general warming effect of the plastic covering on the greenhouses is obvious. A much smaller temperature effect was experienced in the cold frame. Greenhouse GH 2 was surrounded by other structures and this was the probable reason why its average temperatures were the highest. It is difficult to conclude which type of greenhouse was the best since the number of vegetables planted as well as the location of the greenhouse affected the temperature.

Table 6 Average air temperatures at Fort Chimo, Quebec, June to September inclusive

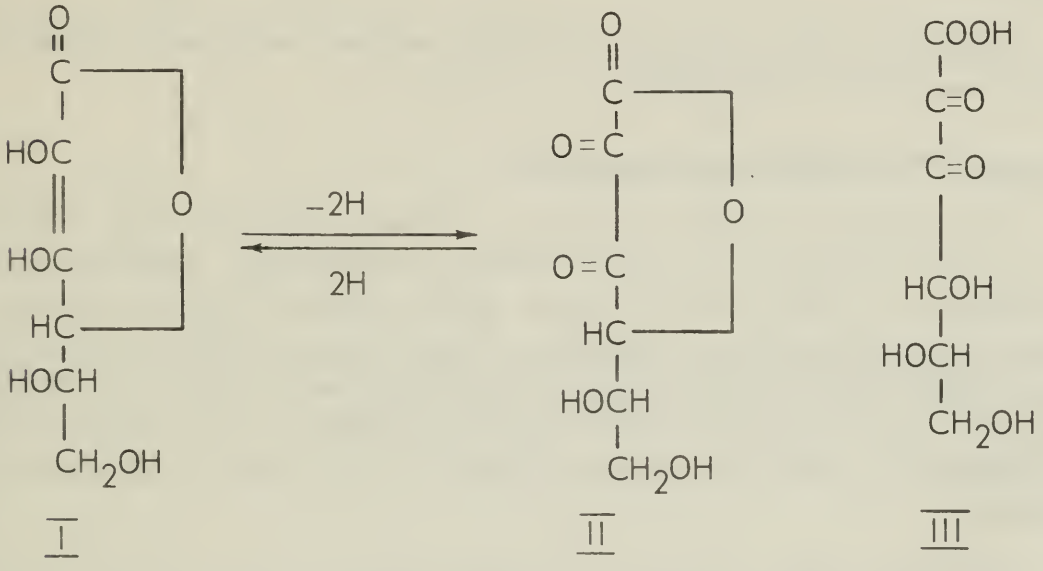
Location	Year	Time of measurement		Average temperature, (degrees F)					
		am	pm	am	max	min	pm	max	min
Greenhouse 1	1965	9:00	6:00	65.0			68.1		
Greenhouse 2	1965	9:00	6:00	72.2			70.4		
Greenhouse 3	1965	8:00	5:00	55.2	66.4	43.4	64.7	76.1	54.1
Greenhouse 4	1965	8:00	5:00	61.8	71.4	42.5	66.5	79.6	57.0
Cold frame	1965	8:00	5:00	50.9			57.4		
Weather cage	1965				53.8	38.6		55.9	44.7
Weather cage	[1]964				56.1	40.3		59.5	46.8

DEVELOPMENT OF SUITABLE CHEMICAL METHODS FOR THE DETERMINATION OF ASCORBIC ACID AND CAROTENE

Ascorbic Acid (Vitamin C) in Vegetables

Physiologically, vitamin C plays a fundamental role in the maintenance of intercellular substances. In the absence of the protection offered by this vitamin, humans develop the condition known as scurvy. Although the curative action of citrus fruits against scurvy has been known since 1752, the structure of the active ingredient, ascorbic acid, was established by degradation and by synthesis only in 1933.

Chemically, L-ascorbic acid (I) is a strong reducing agent and is reversibly oxidized to dehydro-L-ascorbic acid (II). Both I and II have vitamin C activity, but II is relatively unstable and undergoes hydrolysis to the more stable diketo-L-gulonic acid (III), which is devoid of vitamin C activity.



Most of the satisfactory chemical methods for the determination of ascorbic acid fall into the following two categories: oxidation-reduction methods based on the color intensities of 2, 6 -dichlorophenolindophenol solutions, and methods involving oxidation of the vitamin to dehydroascorbic acid followed by the formation and colorimetric estimation of the 2, 4 -dinitrophenylhydrazine derivative. Analytical results include both the ascorbic

acid and the dehydroascorbic acid contents. Studies by Roe and Oesterling (17) show that most plant tissues, especially if fresh, contained little dehydroascorbic acid. If much dehydroascorbic acid were present in any sample, indophenol methods would, of course, be inadequate.

In order to minimize changes before chemical analysis, extraction of ascorbic acid from vegetables should be carried out as soon as possible after the raw products are harvested. The most successful methods of extracting vitamin C utilize either metaphosphoric or oxalic acids. These stabilize vitamin C and prevent catalytic oxidation by complexing heavy metal ions such as copper.

During the selection and adaptation of a suitable chemical method at Fort Chimo, the limitations of laboratory facilities and scientific equipment imposed by the geographical isolation of the test area were constantly kept in mind. Once a suitable, comparatively simple method was developed, it was considered advisable to compare the results obtained with results from a more comprehensive method. In this way the applicability, accuracy and reliability of the simpler method could be established and periodically monitored.

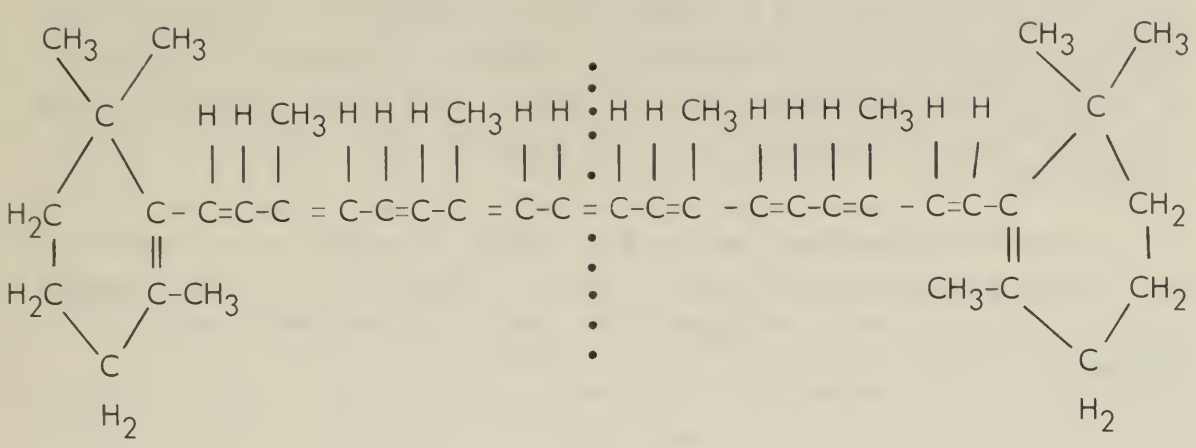
Details of both methods, as finally adopted, and some comparative results are given in Appendix 2.

Carotene (Provitamin A) in Vegetables

All vertebrates require vitamin A. A dietary deficiency may result in such typical symptoms as night blindness, poor growth, nervousness and disturbances of skin and eye tissues. While vitamin A occurs naturally in animals only, the body can synthesize it from some of a group of plant pigments (light yellow to purple) known as the carotenoids. The yellow pigment carotene, first isolated in 1831 from the common carrot, possesses the physiological activity of vitamin A and is a precursor or provitamin of vitamin A.

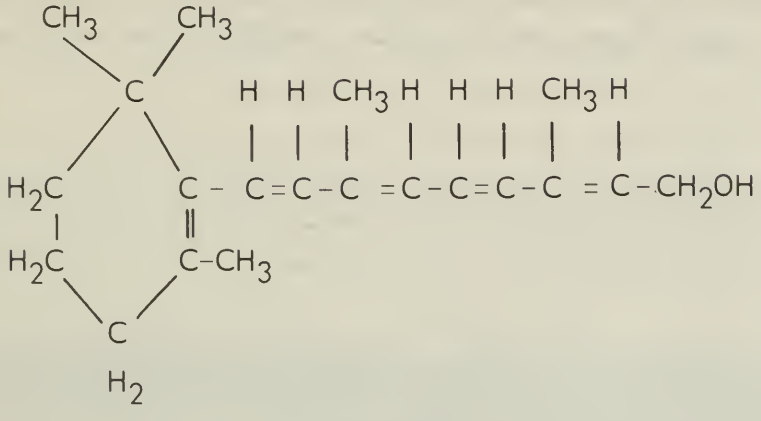
Biological assay by use of vitamin-A-depleted rats is the classical method of establishing the actual vitamin A activity of a food, but such methods are tedious, expensive and subject to errors and variations. Because of this β-carotene analysis is widely used to estimate vitamin A activity of plant materials. That quantity of food which has an activity similar to that produced by 0.6 microgram of standard β-carotene contains 1 international unit (IU) of vitamin A.

Beta-carotene has the following structural formula:



Beta-carotene

When β–carotene is oxidized at the central double bond, two molecules of vitamin A are formed:



Vitamin A

Chemical methods for determining carotene usually incorporate a spectrophotometric or colorimetric endpoint after separation from extracts of the sample by either the chromatographic method or the solvent partition method. The method of the Association of Official Analytical Chemists (A.O.A.C.) (1) employs column chromatography for the separation of carotenoids and is the one most widely used since it is generally applicable to plant materials and gives high accuracy and good reproducibility. However, the method demands the preparation and use of adsorption columns and this requirement was considered to impose a distinct disadvantage for an isolated laboratory.

On the other hand, the relatively rapid solvent partition method requires very simple equipment and is suitable for the analysis of those materials in which the pigment mixture is relatively simple, as in fresh green vegetables. It would not be satisfactory for the analysis of either lycopene-bearing materials such as tomatoes or cryptoxanthin-bearing vegetables such as yellow corn.

The method developed for the Fort Chimo investigation was based on the solvent partition method and it is given in Appendix 3. Results obtained by this procedure were compared with those obtained with the A.O.A.C. method.

RESULTS AND DISCUSSION

Vegetable crops grown in various greenhouses and fields at Fort Chimo, as previously described, are listed in Table 7. Data are presented on the varieties of a particular crop, the number of days from seeding to sampling, and the average weight of freshly trimmed samples of individual root, head, tuber, pod or plant that were taken for ascorbic acid and carotene analysis. These average weight figures are not to be considered the potential yield of

Site of field trials at Fort Chimo, Quebec.

crops because the space for growing any specific vegetable was restricted under different treatments imposed. Comments given in Table 7 (beginning on page26) describe the condition and appearance of the vegetables analyzed. Additional information on crop adaptation, choice of variety, potential for growth in the eastern arctic region, and value of these vegetables as a source of ascorbic acid and carotene is given below. "Variety of choice" means the preferred variety of the ones that were tested.

Beans

Outdoors the soil and the air are too cold for proper growth and development of beans. They must be grown in a greenhouse or in crop shelters. Butter beans do fairly well, but broad beans are preferred for growing in the North.

Potential for growth – only fair.

As source of carotene – poor.

Variety grown – Broad Windsor.

Beets

This crop is not adapted for outdoor culture in this region. Usually the roots are small and the leaves are stunted and of extremely dark color. Growth in the greenhouse at Fort Chimo was fair to good, and although in 1964 roots did not develop to any size, the leaves were very acceptable as greens. Early harvest is recommended to overcome woodiness of the roots. As all parts of the plant are nutritious, the entire plant should be eaten.

As source of ascorbic acid in roots – poor.

As source of carotene in tops – good.

Variety of choice – Little Egypt.

Broccoli

Broccoli has to be sown in flats in the greenhouse, singled and transplanted into individual pots, then hardened for one or two weeks before being planted outdoors. Successive cuttings may be made.

Potential for growth – good.

As source of carotene – fairly good.

Variety of choice – Zenith; almost as good, Cleopatra.

Brussels Sprouts

This crop is temperamental, mainly because of seasonal variations. In some years the sprouts are excellent when grown outdoors, but usually they

do best in a greenhouse. Like most crucifers, they have to be started in flats then singled into peat pots before being set down for final production.

Potential for growth – poor to fair.

As source of carotene – poor.

Variety grown – Jade Cross.

Cabbage

This crop is widely adapted as it can withstand cold and even some early frosts. It must be started indoors and singled into individual pots or spaced out as required under various cultural practices. The plants must be properly hardened off before being set outdoors. Cabbage is well adapted for field planting on plastic mulch. It can be harvested fairly late and is easily stored for later use by preserving as many of the outer leaves as possible. These leaves are highest in ascorbic acid.

Potential for growth – excellent.

As source of ascorbic acid – good.

Varieties of choice – June Giant, Bergkabis.

Carrots

When seeded outdoors, carrots are very slow to emerge and because of cold soil the roots are very short. Carrots can be grown with some success in greenhouses like those at this station. Under such conditions, the roots are slender, tender and tasty.

Potential for growth – fair.

As source of ascorbic acid – poor.

Variety of choice – Chantenay.

Cauliflower

This crop must be started in flats, transplanted and handled like broccoli, brussels sprouts, cabbage, celery and head lettuce. Cauliflower does well in the field when clear plastic is used as a mulch. Care is needed to assure white curds by keeping the head well covered. The taste of the cooked vegetable is very good.

Potential for growth – good.

As source of ascorbic acid – very good.

Variety of choice – Early Snowball; next best, Snow Queen.

Celery

This crop can only be grown in greenhouses, hotbeds and cold frames. Even then, much care is needed to produce good tender stalks, and not to allow the plants to become leafy. Leaves, however, may be dried and used for flavoring soups and stews.

Potential for growth – poor.

As source of ascorbic acid – fair.

Variety of choice – Golden Plume.

Cucumbers

The season is too short for outdoor culture of vine crops in this area. They can be grown in greenhouses, however. Pumpkin, squash and cantaloupes require considerable space and for this reason they are not as desirable as cucumbers. Although the fruits are small, the appearance and quality of cucumbers are usually good.

Potential for growth – poor.

As source of ascorbic acid – poor.

Variety of choice – Burpeana Hybrid.

Kohlrabi

This is a novel vegetable with most gardeners, as the bulb or head is an enlargement of the stem above the soil surface. It can be grown outdoors, but only if started early. Kohlrabi grows well in greenhouses and crop shelters, where the seeds are sown direct. Transplanting into individual pots is not necessary.

Potential for growth – fair.

As source of ascorbic acid – good.

Variety of choice – Early White Vienna.

Lettuce, head

Head lettuce requires starting in flats or large pots, then singling into peat pots for individual planting. It is not very well adapted for outdoor culture, although good heads were obtained in some years. When grown in a greenhouse care must be taken not to overwater the leaves because soft rots develop easily.

Potential for growth – poor.

As source of ascorbic acid – poor.

Variety of choice – Great Lakes.

Lettuce, leaf

This crop can be successfully grown, both indoors and in the field. Success in the field depends a great deal on the climate. Like radish, leaf lettuce may be sown every two weeks throughout June and July to provide leaves of good quality.

Potential for growth – good.

As source of ascorbic acid – good.

As source of carotene – good.

Varieties preferred – Grand Rapids, Black Seeded Simpson.

Onions

Only onion sets are recommended. Of these, yellow sets are preferable if sizable bulbs are wanted. Multipliers, however, are excellent as green onions for bunching. The bulbs and tops from both types of sets are very acceptable for table use. Onions grown from seed do not have enough time to mature.

Potential for growth of sets – excellent.

As source of ascorbic acid – good.

Variety of choice – Yellow Sets.

Parsnips

For some reason yet undetermined, parsnips do not grow well in the North. The seeds are very slow to start and the roots are short and not large. However, a few parsnips may be grown in a greenhouse with reasonable success.

Potential for growth – poor.

As source of ascorbic acid – fair.

Variety grown – Hollow Crown.

Peas

This is one crop that has done well in the western sub-Arctic, but it has never been very successful at the Fort Chimo station. Peas may be grown in the greenhouse, but they require staking and tying up. For good growth of plants the seed has to be inoculated.

Potential for growth – fair.

As source of ascorbic acid – good, regardless of maturity of seed.

Variety of choice – Little Marvel.

Potato

This crop is not very useful in the subarctic region. At Fort Chimo some time was gained by sprouting the seed in warm, semidark rooms for 2 or 3 weeks before planting. Potatoes were also grown in mounds so that the plants were raised up away from the cold soil below. Seed pieces were set in nests of 2 to 4 tubers in a mound 4 to 15 inches high. A third method was to start plants under clear plastic mulch. None of these innovations helped to obtain satisfactory harvests. Except as a novelty, potato growing in this region is not recommended, even though the ascorbic acid content of the tubers was somewhat higher than that contained in samples grown in southern Canada.

Potential for growth – poor.

As source of ascorbic acid – fair.

Variety of choice – Green Mountain.

Radish

This is one vegetable that appears to be very easy to grow in this area. It can be sown successively through a long period if grown indoors. In some years, Fort Chimo radishes were ready for use before June 1, when

Eskimo boy with radishes. Behind him are onions. This picture was taken on May 27, when outdoors there was still snow on the ground.

there was still snow on the ground outdoors. The last seeding may be made late in August. To avoid woodiness, the soil should be very fertile but low in nitrogen. Moisture must be adequate.

Potential for growth – excellent.

As source of ascorbic acid – good.

Variety of choice – Champion.

Spinach

In general, spinach is a short-day plant and goes to seed readily if it receives too much light each day, or if it is set back by cold weather in the early stages of growth. This crop can be quite easily grown directly from seed.

Potential for growth – good.

As source of ascorbic acid – good.

As source of carotene – good.

Variety of choice – Long Standing Bloomsdale.

Swiss Chard

This crop does particularly well when grown in a greenhouse of the type at this station. It is not affected by length of day as much as spinach. It can be used over a long period if at first only the lower and side leaves are taken.

Potential for growth – good.

As source of ascorbic acid – poor.

As source of carotene – good.

Varieties of choice – Foordhook Giant, Giant Luccullus.

Turnips

It should be pointed out that two distinct types of plant go under the general name of turnip. Summer turnips, which have white flesh, grow quickly and are soon large enough to use. They are poor keepers, however. The other type, rutabaga or swede turnip, is a slow grower and normally does best later in the season. It stores well for winter use. The Laurentian variety was the only rutabaga tested at Fort Chimo.

Potential for growth: summer turnip – good.
rutabaga – only fair.

As source of ascorbic acid – good, remaining good even after cooking.

Variety – Purple Milan summer turnip.

CONCLUSIONS

Field conditions, soil and climate are not ideal for the production of vegetables at Fort Chimo, Quebec. However, in the 1964 and 1965 trials, satisfactory results were obtained in plastic-covered crop shelters or in the open field when clear plastic mulch was used.

Most cole crops, such as cabbage, broccoli, brussels sprouts and cauliflower, produced well. Radishes, in particular, grew well under all the methods used. Potatoes were not well adapted to this region; tubers were small, but the levels of ascorbic acid were considered to be generally higher than those of potatoes grown in more southern latitudes. Most vegetables tested were fair to good in their content of ascorbic acid or carotene or both. Cabbage was a particularly good source of ascorbic acid, and much better than broccoli, brussels sprouts and carrots.

The work reported here established that many varieties of vegetables can be successfully grown in this area. These vegetables were found to contain adequate amounts of vitamins A and C.

The Fort Chimo Research Substation was closed at the end of the 1965 season. From now on, research in northern agriculture will be concentrated in the western regions at Beaverlodge, Alberta; Fort Simpson, N.W.T.; Fort Vermilion, Alberta; Inuvik, N.W.T.; and Mile 1019, Alaska Highway, Yukon. The production of vegetables of high nutritional value will be stressed. Knowledge gained from the project on which this report is based will provide essential data if any future agricultural work in the Canadian subarctic is undertaken.

Table 7 Appraisal of vegetables, particularly for ascorbic acid and carotene content, grown at the Department of Agriculture Research Substation, Fort Chimo, Quebec

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (µg/g)	Comments[4]
BEET: Roots	Early Wonder	GH 1		116	24/8/64	6	69.4	7.0		Firm, good color, size variable, interiors woody.
	Ruby Queen	GH 1		116	24/8/64	4	103.4	7.5		"
	Extra Early Egyptian	GH 1		116	24/8/64	4	110.7	5.5		"
	Stokes Early Special	GH 1		95	9/8/65	10	104.3	11.0		Good color and appearance.
	Little Egypt	GH 1		95	9/8/65	10	126.8	12.0		Vigorous, good color and appearance.
BEET: Tops										
	Ruby Queen	GH 4		98	23/9/64				56.12	Fair growth, good color and appearance.
	Extra Early Egyptian	GH 4		98	23/9/64				60.28	"
BROCCOLI										
	Cleopatra	CF		119	19/8/64	5	10.6		14.09	Uniform, good color, slightly overmature.
	"	Field	T2	125	25/8/64	1	37.5		28.60	Small curds, uniform, good color and appearance.
	"	Field	T7	125	25/8/64	8	5.8		22.10	"
	Italian Green Sprouting	Field	T6	118	18/8/65				28.87	Vigorous growth, fair appearance.
	Zenith	Field	T6	118	18/8/65				26.20	Very vigorous, good appearance.
BRUSSELS SPROUTS										
	Jade Cross	GH 2		98	23/9/64	50	4.0		7.31	Vigorous plants, sprouts small, color and appearance good.
BUSH BEANS										
	Broad Windsor	GH 1		112	21/8/64	11	40.6		2.28	Vigorous growth, well-filled pods.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (μg/g)	Comments[4]
CABBAGE										
	Bergkabis	GH 2		99	30/7/64		1450.0	43.5		Uniform and firm.
	"	Field	T2; a	139	9/9/64		130.6	71.2		Soft and nonuniform; good color
	"	Field	T3; a	139	9/9/64		204.7	63.0		Oval-shaped heads but firm; appearance and color good..
	"	Field	T4; a	139	9/9/64		227.7	58.6		Oval-shaped heads; soft; color fair.
	"	Field	T6; a	139	9/9/64		264.5	65.0		Oval-shaped heads; appearance and color fair.
	"	Field	T7; a	139	9/9/64		241.5	50.2		Very firm but small; color good.
	"	Field	T6; b	146	16/9/64		422.7	52.1		Firm; appearance and color good.
	"	Field	T7; b	147	17/9/64		241.1	54.9		Firm but small; appearance good.
	June Giant	GH 2		114	14/8/64		2476.5	44.5 (core)		Excellent color, good size and texture.
								70.0 (outer leaves)		
					21/8/64			40.0 (core)		Above cabbage stored since Aug. 14 at 41°F
					26/8/64			39.5 (core)		"
	"	Field	T1; a	139	9/9/64		168.8	61.1		Nonuniform shape; appearance and color fair.
	"	Field	T2; a	139	9/9/64		385.5	84.0		Fairly uniform; firm with good color.
	"	Field	T3; a	139	9/9/64		115.4	104.5		Uniform but very small; firm with good color.
	"	Field	T4; a	139	9/9/64		287.7	69.6		Uniform; firm with good color and appearance.
	"	Field	T5; a	139	9/9/64		214.5	70.9		Very firm; good color and appearance.
	"	Field	T7; a	139	9/9/64		421.5	46.0		Uniform and firm; good color and appearance.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (µg/g)	Comments[4]
CABBAGE (cont.)										
	June Giant	Field	T7; b	146	16/9/64		132.9	68.3		Firm; good color and appearance.
	"	Field	T6; b	146	16/9/64		342.1	56.0		Firm; good color and appearance.
	"	Field	T6; b	147	17/9/64		132.9	78.1		Soft; appearance and color good.
	Earlihead	GH3		119	19/8/65		1023.4	38.0		Large size; firm with good color.
	"	Field	T6	123	23/8/65		344.2	57.9		Small to medium-sized heads; good appearance and color.
	Early Marvel	Field	T6	123	23/8/65		412.5	66.0		Medium-sized heads; good appearance and color.
	Extra Early Viking	Field	T6	123	23/8/65		366.5	70.5		Small to medium size; good appearance and color.
	Copenhagen Market	GH 3		135	4/9/64		831.7	56.5 (outer leaves)		
								44.0 (layer 2 ")		Distribution of ascorbic acid within a single head.
								37.5 (layer 3 ")		
								39.0 (layer 4 ")		
								44.0 (core)		
			Raw Cabbage		29/9/64			67.8		Ascorbic acid content before and after cooking.
			Cooked Cabbage		29/9/64			9.0		
CARROTS										
	Chantenay	GH 2		114	17/9/64	24	42.8	7.8		Excellent yield, vigorous growth, good color.
	Touchon	GH 2		114	17/9/64	39	26.8	6.6		"

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treat - ment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic Acid (mg/100 g)	Carotene (µg/g)	Comments[4]
CAULIFLOWER										
	Early Snowball	GH 2			29/7/64	1	156.0	85.5		Firm curd; fair color and size.
	" "	Field	T6		13/8/65	3	71.5	85.0		Firm curd; medium size; good color.
	Super Snowball	GH 3			6/8/64	1	168.0	78.0		Firm, fairly uniform curd; poor color.
	Snow Queen (Curds)	GH2			14/8/64	1	184.0	83.8		Excellent appearance; uniform and firm.
	Snow Queen (Stalks)	GH2			14/8/64	1	184.0	90.0		
	Idol Original	Field	T6		13/8/65	1	118.0	92.0		Firm curd; medium size; good color.
	Early Abundance	Field	T6		13/8/65	5	27.5	98.0		"
CELERY										
	Golden Plume	GH1		156	25/9/64	8	68.4	10.5		Fair growth, good appearance and color.
	" "	Field		156	25/9/64	10	22.1	20.0		Small, good appearance and color.
	Utah 52-70	GH2		119	19/8/65	1	158.0	14.0		Medium stalks; good appearance and color.
CUCUMBERS										
	Improved Long Green	GH1		121	21/8/64	1	148.8	6.0		Small but firm, good color and appearance.
	Burpeana Hybrid	GH1		110	10/8/65	1	395.7	4.0		Good appearance and uniform.
	Down East Slicer	GH1		110	10/8/65	1	205.7	3.0		"
	Straight 8	GH1		110	10/8/65	1	195.0	5.0		"
KOHLRABI										
	Early White Vienna	GH1		91	31/7/64	4	180.0	43.0		Firm heads, good size and color.
	" " "	GH2		87	24/8/64	3	145.3	46.5		"
	" " "	GH1		83	28/7/65	6	115.8	48.3		Small, very good appearance, firm interiors.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (μg/g)	Comments[4]
KOHLRABI (cont.)	Early Purple Vienna	GH1		83	28/7/65	4	106.1	53.0		Small, very good appearance, firm interiors.
LETTUCE: Head										
	Pennlake	GH2			3/9/64			11.0		Small; firm, uniform head; good color.
	Great Lakes	GH2			3/9/64			4.0		Large, vigorous head; good appearance and color.
LETTUCE: Leaf										
	Salad Bowl	GH1		53	22/6/64	1	52.0	40.4		Good appearance.
	" "	GH1		54	15/7/64	3	31.3	29.5		"
	" "	GH2		54	12/8/64	4	23.9		29.85	Good growth and color; some overmature.
	" "	GH3		50	18/8/64	3	17.3	34.0		
	" "	CF		65	19/8/64	4	18.3		35.00	Poor yield; past optimum harvest.
	Black Seeded Simpson	GH1		53	22/6/64	1	44.0	36.3		
	"	GH1		59	20/7/64	2	26.0	30.0		Poor germination and growth; fair appearance.
	"	GH1		37	31/7/64	8	10.6	34.0		Poor yield and growth; good appearance.
	"	GH3		50	18/8/64	2	22.2	28.0		
	"	GH3		62	10/8/65	4	51.3	24.0	24.99	Good growth and color; slow maturation.
	"	CF		65	19/8/64	3	6.6		23.75	Poor yield; past optimum harvest.
	Grand Rapids	GH1		55	24/6/64	8	22.3	33.1		Overmature; soft leaves with brown edges.
	"	GH1		54	15/7/64	7	9.9	23.5		Overmature; leaf edges brown.
	"	GH2		57	23/7/64	3	23.3	35.0		Vigorous plants; good color and appearance.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (μg/g)	Comments[4]
LETTUCE: Leaf (cont.)	Grand Rapids	GH1		37	31/7/64	8	8.3	42.0		Poor yield; good appearance.
	"	GH2		54	12/8/64	6	15.0		35.20	Good growth and color; some overmature.
	"	Field	T6	55	31/8/64	2	59.3	25.0		Good appearance; leaves brown and wilted at edges.
	"	Field	T7	58	3/9/64	2	14.4	26.0		Small; appearance and color good.
	"	GH3		55	3/8/65	5	81.3	20.0	43.50	Good growth and color; slow maturation.
	"	Field	T7	58	2/9/64	2	14.4		25.35	Small plants; good color and appearance.
	"	Field	T6	58	2/9/64	1	28.0		31.83	"
	Salad Ice	GH1		61	30/6/64	8	28.0	46.5		
	"	GH1		59	20/7/64	2	33.0	31.9		Poor germination and growth; fair appearance.
	"	GH1		37	31/7/64	3	26.7	31.0		Poor yield and growth; good appearance.
	"	Field	T6	55	31/8/64	1	99.6	34.0		Vigorous plants; good color and appearance.
	"	CF		65	19/8/64	2	19.5		31.20	Poor yield; past optimum harvest.
	"	Field	T6	58	2/9/64	1	40.1		39.98	Good growth, color and appearance.
	Ruby Red	GH1		60	29/6/64	8	28.8	31.0		Poor yield; leaves soft; fair appearance.
	"	GH2		54	12/8/64	5	4.4		24.38	Poor yield; good appearance.
	Paris Island Cos	GH3		62	10/8/65	4	62.0	20.0		Good growth and color; slow maturation.
ONIONS										
	Yellow Sets	GH3		46	24/7/64	14	18.0	bulbs 24.5		Good yield, size, color and appearance.
	"	GH4		49	18/8/64	11	14.2	" 19.0		Firm, good color and appearance.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (μg/g)	Comments[4]
ONIONS (cont.)										
	Yellow Sets	Field		58	16/9/64	80	7.6	bulbs 26.4 tops 56.6		Vigorous growth, good color, yield and appearance.
	"	GH3		56	4/8/65	12	17.4	bulbs 26.0 tops 35.0		Vigorous growth and good yield.
	"	Field		51	19/8/65	73	15.0	bulbs 35.2 tops 82.4		Vigorous growth, good yield and appearance.
	Multipliers (Sets)	GH3		46	24/7/64	10	36.8	bulbs 11.5		Good yield, size, color and appearance.
	"	GH3		56	4/8/65	7	40.2	bulbs 14.0 tops 35.0		Vigorous growth and good yield.
PARSNIPS										
	Hollow Crown	GH2		122	25/9/64	10	13.4	28.5		Small; appearance good.
PEAS										
	Midfreezer	GH1		74	14/8/64	38	5.2	30.3		Excellent peas, firm, well-filled pods.
	"	GH3		87	3/9/64	18	14.3	35.0		Several large, well-filled pods; others small.
	Laxton's Progress	GH1		74	14/8/64	11	4.5	32.5		Excellent peas, firm, well-filled pods.
	"	GH3		87	3/9/64	21	9.8	34.0		Some large, well-filled pods; good color.
	America Wonder	GH1		89	3/8/65	114	4.6	27.0		Fair growth; good appearance; firm pods.
	Little Marvel	GH1		89	3/8/65	125	5.2	31.0		"
	Kenblue	GH1		95	9/8/65	138	4.6	32.0		"

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number of mounds	Weight per mound	Ascorbic acid (mg/100 g)	Carotene (µg/g)	Comments[4]
POTATOES										
	Sebago	Field	M1;b	74	11/9/64	2	155.0	13.0		Firm tubers; color and appearance good; smooth skins. Tubers were small varying from 1 to 3" in diameter.
	"	Field	M2;b	74	11/9/64	4	52.1	14.0		"
	"	Field	M3;b	74	11/9/64	8	13.9	14.5		"
	"	Field	M3;T6;e	74	11/9/64	16	10.5	16.1		"
	"	Field	M3;T3;d	74	11/9/64	16	28.0	15.8		"
	Green Mountain	Field	M3;T6;b	74	11/9/64	16	15.7	13.0		"
	"	Field	M3;T3;d	74	11/9/64	16	23.9	14.0		"
	"	Field	M3;T7;e	74	11/9/64	16	20.6	14.0		"
	"	Field	M3;T6;d		24/8/65	1	74.0	14.0		Excellent appearance; surface smooth; very small (1-1½" in diameter).
	Stored Potatoes				17/9/64			9.8		Grown at False River and left in cool storage.
	"				25/9/64			9.0		"
						Number in composite sample[3]	Average trimmed green wt (g)			
RADISH	Champion	GH1		40	9/6/64	30	8.7	29.0		Good color, firm interiors, uniform size.
	"	GH1		40	24/6/64	31	10.6	27.8		Good appearance and size, larger roots woody.
	"	GH1		39	7/7/64	26	7.0	25.3		Poor appearance, quality and size.
	"	GH1		38	20/7/64	21	14.4	31.5		Poor yield, interiors woody.
	"	GH2		35	29/6/64	20	8.8	35.8		Excellent quality, poor yield.
	"	GH2		34	13/7/64	15	7.7	30.0		Good appearance and size.
	"	GH2		40	27/7/64	22	16.1	26.5		Good size and color but slightly woody.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (μg/g)	Comments[4]
RADISH (cont.)										
	Champion	GH2		30	6/8/64	20	9.4	30.5		Skin rough, roots firm but interiors woody.
	"	GH3		42	20/7/64	13	11.2	23.0		Good size, interiors woody.
	"	GH4		40	27/7/64	18	21.6	26.5		Firm color and size fair but slightly woody.
	"	GH4		34	3/8/64	11	5.8	38.5		Fair appearance, skin rough, interiors woody.
	"	GH4		34	18/8/64	6	11.8	23.0		Good yield, color and appearance; firm interiors.
	"	Field		56	31/8/64	52	6.6	26.0		Good color and firm but interiors woody.
	"	Field		57	15/9/64	43	7.5	40.0		Vigorous, firm, good color and growth.
	Comet	GH1		40	9/6/64	28	7.5	27.4		Good color but large roots were woody.
	"	GH1		40	24/6/64	19	7.6	35.5		Fair appearance, interiors woody.
	"	GH1		39	7/7/64	13	4.2	25.0		Poor appearance, quality and size.
	"	GH1		38	20/7/64	23	6.1	33.0		Poor yield, interiors woody.
	"	GH2		38	2/7/64	19	8.9	35.5		Excellent quality.
	"	GH2		34	13/7/64	20	6.4	28.5		Good appearance and size.
	"	GH3		42	20/7/64	13	8.9	22.5		Good size but interiors woody.
	"	GH4		40	27/7/64	18	13.8	27.0		Firm, color and size fair but slightly woody.
	"	Field		56	31/8/64	26	5.0	26.0		Good color, firm, fair yield, interiors woody.
	Early Scarlet Globe	GH1		40	9/6/64	38	8.1	28.0		Good color but large roots were woody.
	"	GH1		40	24/6/64	44	8.7	33.0		Fair appearance, small size, interiors woody.
	"	GH4		40	27/7/64	19	15.0	26.5		Firm, color and size fair, slightly woody.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (μg/g)	Comments[4]
RADISH (cont.)										
	Cherry Belle	GH2		38	29/6/64	37	9.1	37.0		Excellent quality.
	"	GH2		34	13/7/64	16	7.0	28.5		Good appearance and size.
	"	GH4		40	27/7/64	15	7.7	31.0		Firm, color and size fair, slightly woody.
	Cavalier	GH2		41	2/7/64	40	13.5	25.5		Most were small; few large roots were woody.
	"	GH2		34	13/7/64	21	9.0	26.0		Fair appearance, some woody.
	"	GH4		32	27/7/65	22	11.8	23.5		Vigorous growth, good color, interiors firm.
	"	Field		51	19/8/65	67	10.6	31.3		Large and firm.
	Sparkler	GH3		42	20/7/64	9	8.9	25.5		Good size but interiors woody.
	"	GH4		40	27/7/64	11	17.3	30.5		Firm, color and size fair but slightly woody.
	Scarlet Globe Special	GH4		32	27/7/65	19	15.0	26.0		Good color, interiors firm, growth vigorous.
	"	GH4		32	27/7/65	19	10.6	26.5		"
	"	Field		51	19/8/65	77	12.4	28.5		Large and firm.
	Burpee White	GH4		32	27/7/65	17	8.0	29.5		Large and firm.
	French Breakfast	GH4		33	10/8/65	21	15.6	18.0		Good color, interiors firm, growth vigorous.
	"	Field		51	19/8/65	68	12.2	26.0		Soft and hollow in the interior.
SPINACH										
	Long Standing Bloomsdale	GH1		46	2/8/65	6	15.6	42.2	115.00	Small leaves; good color and appearance.
	"	Field	T6	50	25/8/64	1	59.8		61.04	Large vigorous leaves; good color; some worm damage.
	"	Field	T6	71	15/9/64	16	37.3	127.0		"
	" : leaves " : stalks	Field	T6	50	27/8/64	1	57.4		62.64 7.20	Vigorous growth; slight to medium worm damage to some plants.
	"	Field	T7	71	15/9/64	38	9.9	123.0		Good color; some worm damage.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (μg/g)	Comments[4]
SPINACH (cont.)										
	Old Dominion	GH1		46	2/8/65	5	18.4	36.4	117.75	Vigorous growth; leaves small; good appearance.
	Cold Resistant Savory	GH1		46	2/8/65	3	9.8	26.7	15.25	Poor quality; tendency to bolt.
	New Zealand	GH1		61	30/6/64	25	11.3	23.0		Failed to grow in the field.
	"	GH2		87	28/7/64	15	8.0		30.36	Large, thick leaves; good color.
	America: leaves	Field	T6	50	27/8/64	1	61.9		62.10	Vigorous growth; some worm damage.
	" : stalks								6.04	
	"	Field	T6	71	14/9/64	11	30.3	84.0		Large vigorous leaves; good color.
SWISS CHARD										
	Rhubarb: leaves	GH1		87	28/7/64	4	43.0		68.56	Large vigorous leaves; good color.
	" : stalks								4.83	
	" : leaves	GH2		75	13/8/64	10	17.4		77.24	Excellent yield; several large,
	" : stalks								2.47	vigorous leaves; good color.
	Giant Luccullus									
	" : leaves	GH1		87	28/7/64	7	40.9		58.30	Large, vigorous leaves; good
	" : stalks								2.91	color.
	" : leaves	GH2		75	13/8/64	10	14.7		65.45	Excellent yield; some large
	" : stalks								1.95	leaves; good color.
	Foordhook Giant	GH2		63	2/8/65	8	38.8	6.0	78.25	Excellent leaves; good appearance.
	Burpee's Rhubarb	GH2		63	2/8/65	7	24.8	12.4	81.75	Good color and appearance.
TURNIPS										
	White Milan	GH1		62	30/7/64	5	113.6	29.0		
	"	GH4		62	18/8/64	2	96.4	26.0		Excellent roots.
	"	Field	T6;a+c	67	31/8/64	2	--	44.0		Good yield; large, firm roots; good color; smooth skin; worm damage to leaves.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Carotene (μg/g)	Comments[4]
TURNIPS (cont.)										
	Laurentian	GH2		67	3/9/64	2	227.1	29.0		Firm; good appearance and color; smooth skin.
	"	GH1		98	12/8/65	1	664.0	31.5		Good growth, color and appearance; firm interiors.
	Purple Top White Globe	GH2		73	12/8/65	4	408.2	32.0		Good growth, color and appearance; firm interiors.
	Purple Milan	GH1		62	30/7/64	3	110.0	43.5		
	"	GH4		62	18/8/64	3	158.4	25.0		Excellent roots.
	"	Field	T6;a	67	31/8/64	15	135.3	34.5		Good yield; large, firm roots, good color, smooth skin; worm damage to leaves.
	"	Field	T6;b	67	31/8/64	7	101.1	33.0		"
	"	Field	T6;a+c	67	31/8/64	9	130.9	44.0		"
									Root diameter (inches)	
	"	Field	T1;a+c	88	21/9/64			40.3	1.5	Firm roots; good color and appearance; smooth skin.
								39.1	2.0	
	"	Field	T2;a+c	88	21/9/64			28.0	2.5	"
								35.2	3.0	
	"	Field	T3;a+c	88	21/9/64			36.3	2.5	"
								33.8	3.25	
	"	Field	T4;a+c	88	21/9/64			43.0	1.75	"
								38.7	3.0	
	"	Field	T5;a+c	91	23/9/64			33.5	2.5	Firm roots; good color and appearance; skin at top of some roots is rough.
	"	Field	T6; a+c	91	23/9/64			31.9	3.25	"
	"	Field	T7;b	91	23/9/64			31.9	2.75	"
	"	Field	T7;a	91	23/9/64			52.0	2.5	"
	"	Field	T7	91	23/9/64			30.5	2.5	"
	"	Field			29/9/64			32.7	2.5	Raw turnip.
								28.8		After cooking.

Table 7 (cont.)

Kind of crop	Variety	Where grown[1]	Field treatment[2]	Days to mature	Date of analysis	Number in composite sample[3]	Average trimmed green wt (g)	Ascorbic acid (mg/100 g)	Root diameter (inches)	Comments[4]
TURNIPS (cont.)										
	Purple Milan	Field			29/9/64			31.3	3.0	Raw turnip.
								18.4		After cooking.

[1] Letters GH 1, etc., denote type of greenhouse as described in text. CF stands for cold frame.
[2] Letters T1 to T7 denote type of mulch as described in text.
a = 10-30-10 400 lb/acre; b = 10-30-10 800 lb/acre; c = 4-24-12 200 lb/acre; d = 10-30-10 1200 lb/acre; e = 4-24-12 1200 lb/acre.
M = planted in mounds or hills; M1 = 15" high; M2 = 9" high; M3 = 4" high.
[3] Number of roots, heads, pods, tubers, plants, etc., of respective crop composited for analysis.
[4] For further comments and assessment see text.

APPENDIX 1

REQUIREMENTS OF THE ANALYTICAL LABORATORY AT FORT CHIMO, QUEBEC

Quantity	Description	Cost
1	Colorimeter, photoelectric clinical model, Klett-Summerson	$ 221.40
12	Test tubes for colorimeter	6.40
1	Color filter, KS-50 for colorimeter	13.50
1	Barnstead still, 1 gal/hr capacity	195.00
1	Vacuum pump	265.00
1	Analytical balance	380.00
1	Stirring hot plate	95.00
1	Waring Blendor mixer	26.70
3	Spare blending blade assemblies	10.50
1	Filtrator	50.00
1	Separatory funnel holder, 50 ml	10.00
1	Separatory funnel holder, 500 ml	25.00
1	Propane gas cylinder (100 lb) and valves	20.45
1	Carboy, polyethylene, 6½ gal	13.14
1	Carboy, aspirator with spigot, carrying handle	24.43
1	Balance dish, aluminum, 30 ml	2.50
3	Jars, pyrex glass with covers	10.95
4	Funnels, Buchner, size 3	23.44
3	Funnels, Buchner, size 0	6.36
3 boxes	Filter paper, Whatman #41, 9 cm	5.25
3 boxes	Filter paper, Whatman #42, 9 cm	5.25
3 boxes	Filter paper, Whatman #1, 9 cm	1.20
3 boxes	Filter paper, Whatman #1, 4.25 cm	.57
5	Flasks, filtering, 1 liter	14.20
18	Centrifuge tubes, 50 ml	60.75
6	Bottles, dropping, 60 ml	11.70
3	Bottles, washing, 125 ml	1.50
3	Bottles, washing, 250 ml	1.83
3 pairs	Gloves, rubber, size 9	3.75
2	Bottles, reagent HCl and HnO_3	1.64
2	Bottles, colored, reagent	2.50
2	Bottles, washing, 1 liter	12.80
2	Brushes	.46
3	Spoonula	4.50
1	Pipette support	10.00
3	Flasks, volumetric, 50 ml	8.25

12	Flasks, volumetric, 100 ml	32.40
6	Flasks, volumetric, 200 ml	21.70
8	Flasks, volumetric, 500 ml	33.12
6	Flasks, volumetric, 1000 ml	30.51
1	Burette support	13.00
1	Clamp, double burette holder	4.75
2	Meniscus readers	.90
2	Burettes, 50 ml	24.59
1	Stopcock grease, silicone, 2 oz	1.25
12	Beakers, Griffin, 250 ml	4.68
6	Beakers, Griffin, 600 ml	3.42
6	Beakers, Griffin, 800 ml	4.20
2	Beakers, Griffin, 1000 ml	2.20
2	Cylinders, graduated, 250 ml	7.44
2	Cylinders, graduated, 500 ml	11.64
2	Funnels, powder, 60 mm diameter	1.30
2	Flasks, Erlenmeyer, 1000 ml	1.98
2	Forceps	1.20
1	Burner, for propane gas	5.00
1	Lighter	.50
12	Lighter tips	2.16
1	Tripod, size C	2.25
1	Tongs	.60
12	Wire gauze squares, 6 x 6	3.84
3	Pipettes, volumetric, fast rate, 1 ml	3.60
3	Pipettes, volumetric, fast rate, 2 ml	3.60
3	Pipettes, volumetric, fast rate, 3 ml	3.90
3	Pipettes, volumetric, fast rate, 4 ml	3.90
3	Pipettes, volumetric, fast rate, 5 ml	3.90
3	Pipettes, volumetric, fast rate, 10 ml	4.35
2	Pipettes, volumetric, fast rate, 25 ml	3.60
1	Pipette, volumetric, fast rate, 75 ml	3.25

Assortment of various T-joints, glass tubing, plastic tubing, rubber tubing and rubber stoppers

6 x 1 lb	m-phosphoric acid, pellets	14.10
1 box of 10	Capsules dichlorobenzenenone indophenol sodium salt	7.32
1 pint	Sodium hydroxide solution, 0.8 *N*	1.45
1 lb	Citric acid, granular	1.25
1 lb	Sodium phosphate, dibasic	2.65
6 x 1 qt	Xylene	7.80
1 pint	Bromcresol green solution, 0.04%	3.50
1 lb	Potassium dichromate, technical	1.25
5 lb	Sodium bicarbonate, USP	2.40

2 x 1 qt	Acetone	2.20
4 x 1 gal	Diacetone alcohol, technical	24.88
7 x 1 gal	n-hexane, ACS certified	32.76
1 qt	Methanol, certified	3.24
1 lb	Potassium hydroxide, pellets, ACS certified	2.09
5 lb	Sodium sulphate, anhydrous, ACS certified	7.70
5 g	Carotene (100% Beta)	4.27

APPENDIX 2

TWO METHODS FOR THE DETERMINATION OF ASCORBIC ACID (VITAMIN C) IN VEGETABLES

1. A MODIFIED 2,6-DICHLOROPHENOLINDOPHENOL METHOD

Methods based on 2,6 dichlorophenolindophenol seemed to offer the best starting point for the investigation. Various titration methods that were tried first had to be discarded because of uncertainty in the endpoint. A method reported by Pepkowitz (19) in which the unreduced dye was extracted into xylene offered a possible way around this difficulty. Following preliminary work which indicated that reproducible results were attainable with relatively simple equipment, a procedure suitable for an isolated location was developed.

Reagents

1. Metaphosphoric acid, 5% aqueous (Fisher Reagent A-243). Store in the cold.
2. L-ascorbic acid, 0.02% (290 μg/ml) in 3% aqueous metaphosphoric acid (Fisher Reagent A-61). Dissolve 0.1000 g in 500 ml of 3% metaphosphoric acid solution and store in the dark. Make fresh before using.
3. Sodium 2,6-dichlorobenzenone indophenol, 0.006% aqueous (Fisher Reagent S-286). Dissolve 0.012 g in 200 ml hot water, cool and filter (Whatman 42 paper). Store in brown bottle in the cold.
4. Sodium hydroxide, 0.08 *N*. Dissolve 32 g sodium hydroxide in 1 liter of water and dilute 10 ml to 100 ml with water.
5. Phosphate-citrate buffer, pH 4.0. Dissolve 1.92 g citric acid (Fisher Reagent A-109) in 100 ml water. Separately dissolve 3.56 g disodium phosphate heptahydrate (Fisher Reagent S-373) in 100 ml water. Add the phosphate solution to the citric acid solution to give a final pH of 4.0 (approximately 85.5 ml of phosphate solution are required). Store in the cold.

6. Bromcresol green indicator, 0.04% (Fisher Reagent 5-985-G).
7. Xylene (Fisher Reagent X-5).

Procedure

Weigh 50.00 g of the clean fresh vegetable, dice into a Waring Blendor containing 200 ml of Reagent 1, blend until uniform (3 to 5 min), filter (Whatman 41 paper), wash with Reagent 1 and make up to 500 ml with washings.

Place an aliquot (usually 2.00 ml) containing less than 100 μg ascorbic acid in a 60-ml separatory funnel, add 4 drops of indicator (Reagent 6) (solution turns yellow), and add sodium hydroxide solution (Reagent 4) dropwise until the solution turns green. Add 1 ml of buffer (Reagent 5) and immediately add 4.00 ml of dye solution (Reagent 3) followed by 10.00 ml xylene (Reagent 7). Shake well and allow the layers to separate. After about 30 min, decant the red-colored xylene layer slowly and read on a Klett-Summerson colorimeter (No. 50 Filter). Estimate concentration of ascorbic acid from a standard calibration curve prepared as described below.

Calibration curve

Prepare a series of standard solutions in 100-ml volumetric flasks by diluting 0, 5.00, 10.00, 15.00, 20.00, 25.00, 30.00, 35.00 and 50.00 ml of Reagent 2 to the mark with metaphosphoric acid (Reagent 1). Place a 1.00-ml aliquot from each flask in a 50-ml glass-stoppered centrifuge tube, add 2 drops of indicator (Reagent 6) and continue as for the samples. Plot the colorimeter readings (Y-axis) vs μg of ascorbic acid (X-axis).

Calculation

$$\text{mg ascorbic acid/100 g raw vegetable} = \frac{R \times V_1 \times 100}{W_1 \times V_2 \times 1000}$$

where $R = \mu$g of ascorbic acid in V_2

W_1 = weight of original material (50 g)

V_1 = total volume of extract (500 ml)

V_2 = volume of aliquot taken (2 ml)

Comment on method

The 5% metaphosphoric acid reagent (No. 1) was found to be stable for several weeks. This reagent should be replaced with a fresh solution when it is found that the standard curve is not being reproduced.

The spectral curve of the colored complex obtained on a recording

spectrophotometer showed a very gradual maximum centered at 500 mμ. The Klett Filter No. 50 transmitted between 470 and 530 mμ.

2. A MODIFIED 2,4-DINITROPHENYLHYDRAZINE METHOD

The procedure for this method was adapted from the report by the Committee on Collaborative Assay of the Association of Vitamin Chemists, Inc. (20).

Reagents

1. Metaphosphoric acid, 1% aqueous (Fisher Reagent A-243). Store in the cold.
2. 10% metaphosphoric acid – 20% acetic acid solution. Dissolve 200 g metaphosphoric acid in approximately 1200 ml water, add 400 ml glacial acetic acid and dilute to 2000 ml with water.
3. 5% metaphosphoric acid – 10% acetic acid solution. Dilute 500 ml of Reagent 2 to 1 liter with water.
4. 5% metaphosphoric acid – 10% acetic acid solution containing 1% thiourea. Add 10 g of thiourea to 500 ml of Reagent 2 and dilute to 1 liter with water.
5. Sulphuric acid, 9 *N*. Slowly add 250 ml concentrated sulphuric acid (sp. gr. 1.84) to 700 ml water, cool and dilute to 1 liter with water.
6. 2,4-dinitrophenylhydrazine, 2% in 9 *N* sulphuric acid. Dissolve 2 g of 2,4-dinitrophenylhydrazine (Matheson, Coleman & Bell No. 6129) in 100 ml of Reagent 5, filter (Whatman 42 paper), and store in the refrigerator. Prepare fresh solution after two weeks.
7. Sulphuric acid, 85%. Cautiously add 900 ml concentrated sulphuric acid (sp. gr. 1.84) to 100 ml water.
8. Norite, acid washed. Dilute 100 ml of concentrated hydrochloric acid (sp. gr. 1.19) to 1 liter with water. Place 200 g norite in a large beaker, add the dilute hydrochloric acid solution, heat to boiling and filter with suction (Whatman 1 paper). Return the norite to the beaker, stir with 1 liter of water and filter. Repeat this procedure until the washings give a negative or very faint test for ferric ion (make test solution by dissolving 1.94 g KCNS in 100 ml water). Dry the norite thoroughly at 110-120 C.
9. L-ascorbic acid, 0.1% (1000 μg/ml) in metaphosphoric acid - acetic acid solution (Fisher Reagent A-61). Dissolve 0.1000 g in 100 ml of Reagent 2.

Procedure

Weigh 50.00 g of the clean fresh vegetable, dice into a Waring Blendor containing 200 ml of Reagent 1, blend until uniform (3 to 5 min), filter

(Whatman 41 paper), wash with Reagent 1 and make up to 500 ml with washings.

Place 5.00 ml of extract in a 50-ml beaker, add 15 ml of Reagent 4, add 1 g of norite (Reagent 8), stir and filter (Whatman 1 paper). Place 4.00 ml of the filtrate in a Klett tube, and add 1 ml of Reagent 6.

To carry a blank through the procedure, add 1 g of norite to 20 ml of Reagent 4, stir, filter and place a 4.00 ml aliquot in a Klett tube but do not add any Reagent 6.

Place all Klett tubes except the blank in a 37 ± 0.5 C water bath for 3 hours to allow osazone formation. Remove tubes from water bath and place all tubes including the blank in an ice bath. Add 5 ml sulphuric acid solution (Reagent 7) dropwise to each tube and, in addition, 1 ml of Reagent 6 to the blank tube only. Place plastic stoppers in each tube and mix well. Set aside for 45 min at room temperature before reading on the Klett-Summerson colorimeter (Filter No. 50). Estimate concentration of ascorbic acid from a standard calibration curve as prepared below.

Calibration curve

Make a working standard ascorbic acid solution (30 μg/ml) by diluting 3.00 ml of Reagent 9 to 100 ml with Reagent 3. Place 0, 2.00, 4.00, 6.00, 8.00 and 10.00 ml aliquots in a 50-ml beaker, add enough Reagent 4 to make the total volume 20 ml, add 1 g of norite (Reagent 8), mix and filter (Whatman 1 paper) into a 200-ml beaker. Pipette 4.00 ml of filtrate into a Klett tube, add 1 ml of Reagent 6 to all except the blank and continue exactly as described above for the samples. Plot the colorimeter readings (Y-axis) vs μg of ascorbic acid (X-axis).

Calculation

$$\text{mg ascorbic acid/100 g raw vegetable} = \frac{R \times V_1 \times 20 \times 100}{W_1 \times V_2 \times V_3 \times 1000}$$

where R = μg of ascorbic acid in V_3

W_1 = weight of original material (50 g)

V_1 = total volume of extract (500 ml)

V_2 = original aliquot taken (5 ml)

V_3 = aliquot taken from final filtrate (4 ml)

Comment on method

Addition of 85% sulphuric acid solution will cause darkening of solutions containing sugars if added too rapidly or if the temperature is allowed to rise. The function of the ice bath is to help prevent this.

Table 8 Recoveries of ascorbic acid from vegetable extracts

Vegetable	Ascorbic acid			
	Method 1		Method 2	
	Added µg	Recovered µg	Added µg	Recovered µg
Cabbage	20.0	20.0	12.0	12.2
	30.0	27.0		
Potato	20.0	18.0	12.0	12.1
	30.0	27.6	36.0	32.7
	50.0	55.2		
Radish	10.0	10.8	12.0	13.5
	20.0	18.4	36.0	33.0
	30.0	24.7		
	30.0	30.5		

Table 9 Comparison of results for ascorbic acid

Vegetable	Ascorbic acid (mg/100 g)					
	Method 1			Method 2		
Cabbage		60.8			66.3	
		68.0			68.7	
	50.0		51.2	47.0		45.8
	52.0		51.2	45.8		47.3
Radish		25.4			24.0	
		26.0			22.5	
		21.5		20.1		17.0
		16.8		18.5		18.3
	23.0	21.8	23.0			
Potato		6.8			11.8	
		6.5			9.5	
		10.5		10.0		9.5

Recoveries of Ascorbic Acid

Ascorbic acid was added to extracts of vegetables and recoveries were checked by both methods. Table 8 shows that highly acceptable recoveries were obtained by both procedures.

The efficiency of the extraction procedure was checked by analyzing the vegetable solids remaining after extraction. Since negligible amounts of ascorbic acid were found, it can be concluded that the extraction procedure was quantitative.

Results and Discussion

A comparison of results obtained by the two methods is shown in Table 9. Replicate analyses from a single extract are shown on the same line. It is evident that reproducibility and precision of results were good.

The first two samples of potatoes had been stored over an extensive period. Since method 2 gave higher results than method 1, it would appear that a considerable portion of the ascorbic acid had changed to dehydroascorbic acid.

The results indicated that either method could be used if the analyses were performed on freshly harvested vegetables. Since method 1 is less exacting and requires simpler equipment, it was chosen for the work at the Fort Chimo Substation.

Although it is common agricultural practice to report results on a dry matter basis, it was decided to follow the usage of the Association of Vitamin Chemists (20) who report as "mg per 100 g of raw vegetable" because of the difficulty of transporting a drying oven to an isolated station.

APPENDIX 3

THE DETERMINATION OF CAROTENE BY SOLVENT PARTITION IN DIACETONE ALCOHOL

The method is essentially that of Beadle and Zscheile (21) and it is based upon the differential solubility of carotene in diacetone alcohol and petroleum ether from the other fat-soluble pigments. Purified carotene is estimated from readings taken on a Klett-Summerson colorimeter with a No. 44 filter.

Reagents

1. Diacetone alcohol, technical (Fisher No. D-17).
2. Aqueous diacetone alcohol, 100:6. Mix 100 volumes of diacetone alcohol with 6 volumes of water.
3. Hexane, boiling range 67-70 C (B.D.H.).
4. Methanolic potassium hydroxide solution. Dissolve 20 g of KOH in 100 ml of absolute methanol.
5. Anhydrous sodium sulphate, granular (B.D.H.).
6. Carotene, 100% beta (Eastman Organic Chemicals No. 3702).

Procedure

Place representative sample (5.00 or 10.00 g, depending on carotene content) in Waring Blendor, add 125 ml diacetone alcohol (Reagent 1), blend for 5 minutes and filter (250-ml suction flask, Buchner funnel, No. 42 Whatman paper). Transfer quantitatively to 500-ml separatory funnel, add hexane (Reagent 3) in increments of 25 ml and shake for one minute after each addition. Continue adding hexane as above until two phases are formed. Extract with successive portions (50 ml each) of hexane until all the yellow pigments have been removed from the diacetone alcohol phase. (At least 4 extractions are required.)

Combine the hexane extracts and wash by shaking for one minute with three successive portions of aqueous diacetone alcohol (Reagent 2), followed by one washing with methanolic KOH solution (Reagent 4). Continue purifying the hexane extract by shaking for one minute with three successive portions of water (100 ml) and filter through a layer of anhydrous sodium sulphate (Reagent 5) held on a filter paper (Whatman No. 1) into a glass-stoppered flask. Wash the sodium sulphate and paper with small portions of fresh hexane, mix the carotene extract thoroughly and measure its volume (graduated cylinder).

Read on a Klett-Summerson colorimeter (KS 44 filter) and estimate the carotene content by comparison with a standard curve prepared as below.

Calibration curve

Place 0.2000 g of carotene (Reagent 6) in a volumetric flask (1 liter), add 10 ml chloroform, shake until dissolved and make to volume with hexane (200 μg/ml). Dilute 10.00 ml to 200 ml with hexane (10 ug/ml) and place 0, 1.00, 3.00 and 5.00 ml in a series of 10-ml volumetric flasks. Make to volume with hexane, read on the Klett-Summerson colorimeter (KS 44 filter) and plot colorimeter readings (Y-axis) vs micrograms of beta-carotene/ml (X-axis).

Calculation

$$\text{micrograms carotene/g original material} = \frac{R \times V}{W}$$

Where R = graph reading (micrograms of carotene/ml)

W = weight of original material taken

V = volume of carotene extract

Comment on method

The standard graph as plotted from Klett-Summerson readings has a slight curve, but this presents no particular difficulty since the curve is

highly reproducible. When readings on the same standard solutions were taken on a Beckman DU spectrophotometer at a wave length of 447 mμ the graph did come out as a perfectly straight line. The Warren spectrachord showed that these solutions have a comparatively sharp peak with a maximum at 447 to 451 mμ The KS-44 Klett filter transmits light over a broader range (410 to 480 mμ) and this results in a slight curve in the standard graph.

Recoveries of beta-carotene

Recoveries of added amounts of beta-carotene to cabbage extracts proved to be highly acceptable (96% recovery). It was found that three extractions with hexane, as recommended by Beadle and Zscheile, did not remove all the beta-carotene from the combined extract. Good recoveries were obtained only when extraction with hexane was continued until yellow coloring was no longer obtained.

Comparison of results with A.O.A.C. method

Table 10 shows results for samples of spinach obtained locally as analyzed by the proposed method and by the A.O.A.C. method (1).

Table 10 Carotene content of spinach

Partition method (μg/g)	AOAC method (μg/g)
48.95	46.79
45.78	48.70
47.37 (average)	47.75 (average)

Discussion

Since carotene pigments are easily destroyed by bright light, care must be taken to avoid undue exposure. This can be conveniently accomplished by performing all the operations without intermediate delays.

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