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CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF BRITISH COLUMBIA TREE FRUITS

C. C. Strachan, A. W. Moyls, F. E. Atkinson and J. E. Britton

Typical View of Fruit Growing in British Columbia

DEPARTMENT OF AGRICULTURE
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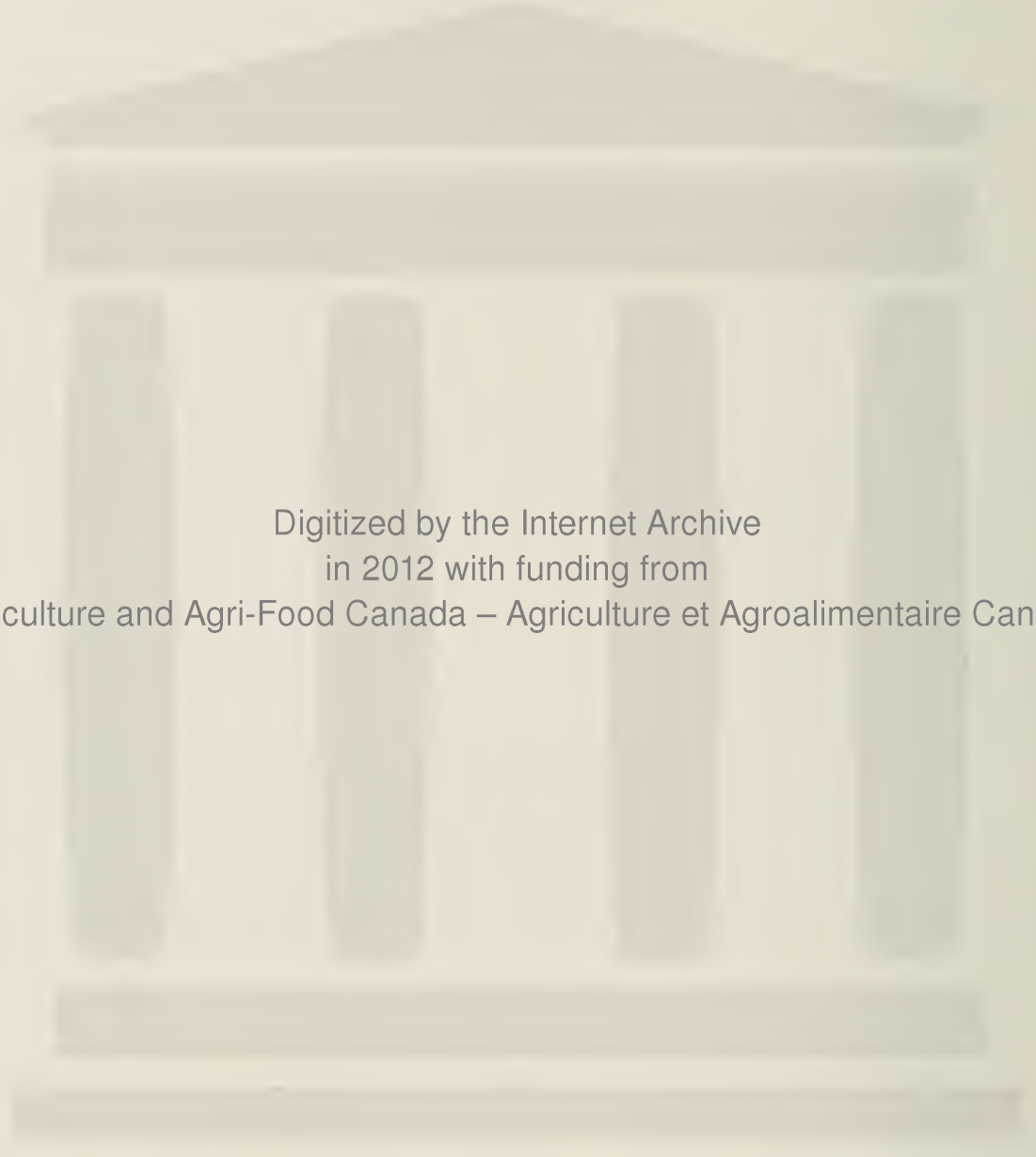

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Canada Department of Agriculture
Experimental Farms Service

CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF BRITISH COLUMBIA TREE FRUITS

A five-year report on a co-operative project with the British Columbia Fruit Growers Association

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DOMINION EXPERIMENTAL STATION
SUMMERLAND, B.C.

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CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF BRITISH COLUMBIA TREE FRUITS

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INTRODUCTION

The investigational work reported here was a co-operative project with the British Columbia Fruit Growers Association conducted during the years 1943 to 1947 inclusive. The purpose was to provide comprehensive information on the chemical composition and nutritive value of British Columbia tree fruits as commercially marketed. The bulletin contains information regarding the origin of the British Columbia Fruit Growers Association research project, the arrangements for financing the work and the reasons why attention was concentrated on studies concerning the nutritive value of fruit. It gives an outline of the procedure followed during the studies and presents fully the results secured.

ORIGIN AND ADMINISTRATION OF THE B.C.F.G.A. RESEARCH PROJECT

The 1943 B.C.F.G.A. convention passed a resolution authorizing an expenditure of up to $5,000 of the Association's funds on research to be conducted at the Dominion Experimental Station, Summerland, B.C. This amount has been appropriated annually. Experiments have been conducted on problems of especial interest to the British Columbia Fruit Growers Association.

OBJECT OF PROJECT TO STUDY NUTRITIVE VALUE OF FRUIT

After consultation with officers of various growers' organizations it was decided to undertake a comprehensive study of the chemical composition and nutritive value of tree fruits grown in British Columbia. It was realized that studies of this nature are technically exacting, laborious, time consuming, expensive and unlikely to produce results of a spectacular nature. On the other hand, it also was realized that world events during the past few years have made people "food conscious". The general public as well as nutritionists and dietitians are now keenly interested in the composition and health value of foods.

At the time this project was started there was very little authentic information available regarding the composition, nutritive value and health promoting properties of Canadian-grown fruits. Such information is valuable to doctors, dietitians and professional home economists. It also is of interest to the housewife who has begun to consider food value as well as the appearance and palatability of foods when making purchases. Reliable information on the nutritive value of fruit can be expected to have a beneficial effect on the national health.

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CONSTITUENTS OF FRUIT AND THEIR RELATION TO NUTRITIVE VALUE

The following general notes regarding the various fruit constituents are presented here together with the terms used and their interpretation in this report.

Refuse

This term refers to the portion of the fruit, such as pits, cores and peelings, commonly discarded in preparation for consumption. Information concerning the percentage of refuse is important to fruit processors as it has a great influence on the pack of the finished product. It also is of interest to the housewife. The percentage of refuse usually is greater in immature than in fully mature fruit. Actually, the material included in refuse may have some health value. For example, the skins of apples have been found to contain appreciable quantities of ascorbic acid.

Edible Portion

This is the portion of the fruit remaining after removal of pits, cores and peelings, which are commonly discarded in preparing any particular fruit for consumption.

Fig. 1. Fruit and Vegetable Products Laboratory, Dominion Experimental Station, Summerland, B.C.

Water

Water content refers to the loss in weight from drying. It is the difference between the weight of the fresh substance and the total solids which it contains. Fruits compared with many other foodstuffs are characterized by a relatively high water content. Partly because of this they sometimes are considered a luxury. Nevertheless the high water content of fruits is in some ways an advantage since it makes them palatable and refreshing. Because of their high water content, fruits provide an agreeable means of taking needed liquid. In the treatment of some illnesses fruits are a very important source of fluid. Normally the more mature and better quality fruit of any one variety has a lower water content than the poorer or less mature fruit.

Total Solids

Total solids content of fruit is what remains after complete removal of the water naturally present. Thus amongst other constituents, the total solids include fibre and other complex carbohydrates, sugars, acid, minerals, protein and fat. In tree fruits of the type grown commercially in British Columbia, carbohydrates, including fibre, comprise usually about 90 per cent of the total solids. The term "total carbohydrates" including fibre refers to solids other than protein, fat and ash. It includes organic acids and undetermined solids as well as the substances correctly classed as carbohydrates. Total solids differ with variety of fruit and are invariably greater in the more mature fruit of any one variety. High total solids for a given variety are associated usually with superior quality.

Water-Insoluble Solids

The term "water-insoluble solids" refers to that portion of the total solids remaining after all soluble matter has been leached away with hot water. In British Columbia tree fruits the water-insoluble solids consist largely of fibre, the complex carbohydrate material found in cell walls. This fibre is sometimes termed "roughage" and is relatively indigestible by the human organism, supplying little or no energy. However, by absorbing water and increasing intestinal bulk, and by their somewhat rough yet not harsh physical nature, these indigestible constituents of fruit stimulate bowel movement. This property of fruits in contributing bulk or roughage to the diet is one of their important functions as food. Furthermore these so-called "insoluble carbohydrates" apparently undergo some changes in the intestines due to bacterial action with resulting beneficial effects on human health. Water-insoluble solids tend to be a fairly constant value for the kind and variety of fruit.

Soluble Solids by Refractometer

The term "soluble solids" refers to that portion of the total solids which are soluble in water. It is the figure obtained by subtracting the "water-insoluble solids" from the "total solids". In fruits the soluble solids are comprised of those substances such as sugar, acid, minerals, pectin, etc., which are in solution, or "liquid phase" of the fruit and hence in relatively available form for assimilation.

The figure secured by the use of the instrument known as the "refractometer" is sometimes loosely termed the "sugar" content. In actual fact the refractometer indicates more accurately the soluble solids or sum of the substances which are water soluble. Hence the figure obtained by use of this instrument is much greater than the true sugar content. However, as sugars constitute from 60 to 85 per cent of the soluble solids, depending on the fruit, the refractometer reading provides a fairly accurate indication of the comparative sugar content of fruits at various stages of maturity. For this reason it can be helpful as an index of maturity, particularly with certain fruits, for example cherries and prunes.

Acid

Acid is the total free acid expressed as the predominant acid in the fruit. Most fruits generally contain one or more acids with one predominating. Tree fruits of the type grown in British Columbia contain largely malic or citric acid. It generally is considered that these two organic acids can be burned in the body to carbon dioxide and water in the same way as sugar, thus they have fuel or calorific value. Acid content varies with the various fruits, tending to decrease slightly with maturity. Acids lend sprightliness to the flavour of fruit and the ratio of acid to sugar influences the palatability.

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Value pH

The value known as "pH" is a logarithmic expression for hydrogen ion concentration. It is a measure of the active acidity of the fruit and is of value in connection with the fruit processing industry. From a dietetic or clinical viewpoint, Bridges and Mattice (36) state, "It is possible that the future will demonstrate that the pH of the food per se is of little moment".

Sugars

The term "sugar as invert" refers to a common basis for calculating the sugars present in fruits. A true invert sugar is 50 per cent dextrose and 50 per cent levulose. Fruits principally contain in varying proportions three sugars, namely, sucrose (or ordinary sugar), levulose, and dextrose. The latter two are grouped together under the heading "reducing sugar", a term derived from one of their characteristic chemical properties. Total sugar is the sum of these three sugars.

Much of the fuel or calorific value of fruits is derived from their sugar content. The sugar varies markedly in fruits with variety, climatic conditions and maturity. High sugar content is invariably associated with more mature and better quality fruit.

Ash (Minerals)

Ash is the residue from burning the dry substance (total solids) until free of carbon. It includes all the minerals in the fruit. The ash of fruits contains small amounts of many minerals, all of which are of value in nutrition, but on the whole, fruits do not supply important amounts of minerals as compared with many other common foodstuffs.

Alkalinity of Ash

The alkalinity of ash value is considered an indication of the potential reserve alkalinity of the fruit. Although most fruits are more or less acid to taste, they contain minerals in the form of organic salts. Usually there is an excess of base-forming over acid-forming elements so that when oxidized or "burned" in the body, these salts yield an alkaline residue which theoretically enables the body to maintain a desirable acid-base ratio. How much practical significance the balance of acid-forming and base-forming elements has in human nutrition has not been settled as yet (143). In general, those fruits with the slightly higher ash content tend to have the greater value for alkalinity of ash.

Pectin

Pectin is the name given to a group of complex carbohydrate substances found in many fruits. Pectin is of importance from the dietetic standpoint because of its detoxifying influence in the intestines. A scraped apple diet has been used for many years in Europe as a home remedy for digestive disturbances. More recently dried apple powders have been used beneficially in the treatment of diarrhoea. Purified pectin, pectin concentrates, and metallic pectinates have been found to have many therapeutic uses. The importance of pectin in the making of jams, jellies and processed products is, of course, well known.

Tannin

Tannin is an organic acid widely distributed in fruits in relatively small yet varying amounts. In the quantities in which tannin occurs in fruits, it probably has no direct nutritional effect, although the tannin and acid content have been suggested as an aid in maintaining intestinal tone and motility (59). Unques-

tionably tannin is important in connection with the palatability of fruits and fruit products. When tannin is present in undesirably large amounts it imparts a bitter or astringent taste and some people may be particularly sensitive to these higher concentrations. However, when present in the proper quantities and blended with sugar, acid and aromatic substances, tannin imparts character to the flavour of fruits.

Ascorbic Acid (Vitamin C)

Ascorbic acid (vitamin C) is a water-soluble vitamin. It originally was known as the anti-scorbutic vitamin because of its value in preventing the malnutrition disease, scurvy. A good deal is now known of the physiological role of ascorbic acid in maintaining good health. It is a dietary essential and is required in relatively large daily quantities. The body cannot store ascorbic acid. There is evidence that many Canadians do not receive sufficient ascorbic acid to maintain optimum health. The best sources of ascorbic acid are fresh fruits and vegetables although these vary markedly in their ascorbic-acid content. Furthermore, ascorbic acid is relatively unstable and disappears rapidly from poorly handled or overmature fruits. Seasonal and climatic conditions affect the ascorbic-acid content of fruit. Clear, bright, sunshiny days are conducive to development of high ascorbic-acid content in fruit. Another important factor is the definite varietal characteristic which makes some varieties high and other varieties of the same kind of fruit low in ascorbic acid. Soils and fertilizers, while not so important as the previous factors, may affect the ascorbic-acid content of the fruit to a limited extent.

Vitamin A (Carotene or Provitamin A)

Vitamin A is a fat-soluble vitamin and like all other dietary essentials is necessary for normal growth and development and for maintenance of health at all ages. A great deal is now known about its physiological role and also the pathological conditions which develop from a deficiency of this vitamin. Vitamin A itself, being formed from precursors (antecedent substances or provitamins) which are found in plants, occurs only in animal products. These provitamins (there are at least four of them) are orange yellow pigments formed in plant foods often called by the group name "carotenoids" or simply "carotene". They are capable of being changed into true vitamin A in the body with varying degrees of efficiency. Provitamin A substances in plant foods (fruits, vegetables, etc.) often are composed largely of beta-carotene, which also has the greatest vitamin A activity of this group, and hence it is frequently used in calculating the vitamin A value of a plant food. There are wide variations in the requirement or utilization of vitamin A and its precursors.

A few fruits are known to be good sources of carotene. In contrast to ascorbic acid, carotene is more stable and not so readily affected by storage or processing. Carotene content of fruit as with ascorbic acid is related to the kind and variety of fruit.

Other Vitamins

Other vitamins, particularly those of the B complex group, are known to be present in tree fruits. These occur in relatively small constant amounts for the various fruits under study and contribute beneficially to the diet. However, other common foodstuffs are much richer sources. Hence these vitamins were omitted from the current investigation.

Protein and Fat

Protein and fat are well known essential groups of nutrients which must be furnished in human food. However, the protein and fat content of fruits were not determined in the present study since numerous authoritative analyses

throughout the world show these constituents to remain relatively constant and in small amount for all fruits. The sum of the values for protein and fat present in tree fruits rarely exceeds one per cent. Many other common foods supply these nutrients in much larger quantities.

Starch

Starch, a carbohydrate, which supplies much of the energy value of many foods, was not determined since in the ripe fruit starch is absent, or present in only insignificant amounts.

Energy Value (Fuel or Calorie Value)

The food energy or fuel value of a food is expressed in calories, which is merely a measure of the energy derived from one or more of the three fundamental food nutrients, namely, protein, fat and carbohydrate.

Proximate Composition

The term "proximate" when used in connection with the chemical analysis of foods means the analysis of the particular food into its components, or the compounds of which it is composed, together with the determination of their proportions. These compounds are all accurately determined. In analyses of fruits proximate composition usually refers to all the main compounds except the individual minerals and vitamins.

REVIEW OF LITERATURE

Proximate Composition

There is very limited information available on the proximate composition of Canadian tree fruits as commercially marketed. Various institutions in Canada may have accumulated certain data for their own particular needs or for some specific problem or purpose. However, this information is scattered and not generally available. Atkinson and Strachan (14) presented limited data concerning the chemical constituents of some fruits grown in British Columbia.

A very comprehensive summary of numerous analytical data on the proximate composition of United States fruits was evaluated and compiled by Chatfield and McLaughlin (45) and published by the United States Department of Agriculture. McCance and Widdowson (100) under the auspices of the British Medical Research Council, published extensive information on the proximate composition of foods, including fruits, which were consumed in Great Britain. These two reports have formed the basis for many of the later published compilations on the proximate composition and energy value of food materials.

McCance and Widdowson (100) also made many analyses of individual mineral constituents. Sherman (143), too, has accumulated information as to the general averages of eight mineral elements occurring in the edible portions of fruits.

No information is given in these publications with respect to tannin, pectin, and a number of other values of interest, nor are data presented showing varietal differences, except in a few instances in a very general way, or differences due to climate or location. The data reported in the literature on pectin, tannin, water-insoluble solids and certain other values, are somewhat limited and incomplete. That data may exist is quite probable, but the information is not easily accessible since the values are scattered throughout investigational reports of various types. There is, however, considerable information available, particu-

larly in the United States, on varietal differences and other factors affecting the proximate composition of certain fruits. Because of the purpose of such investigations much of the information is not applicable for comparison to values obtained in this study. Literature dealing specifically with various fruits and their constituents is discussed later in this bulletin following the presentation of results on each kind of fruit.

Ascorbic Acid and Carotene Content

Literature available on the vitamin content of tree fruits, commonly consumed in Canada is very meagre. Some studies have been reported on ascorbic acid content. Branion *et al.* (35) presented data on the average ascorbic acid content of some fruits, fruit juices, and vegetables commonly used in Canada. Of fresh fruits grown in Canada, only apples, crabapples, and three samples of cherries were analysed by these investigators. Grant (72) reported on the ascorbic acid values of a large number of apple varieties grown in Ontario. Truscott *et al.* (160) recently published the results of investigations of the ascorbic-acid content of a number of fruits and vegetables commonly grown in Ontario. The values presented by Truscott and his associates were obtained for the most part on fruit harvested at optimum maturity and analysed within 1 to 2 days, being refrigerated during any holding period. The writers have been unable to find any data in the literature on the vitamin A content of Canadian tree fruits.

There is a great deal of literature on the vitamin content of most fruit grown in the United States, the papers dealing with ascorbic acid values being particularly numerous. Many of the reported investigations include studies on the vitamin content of foods in relation to variety, method of cultivation, maturity and processing. A very good summary of the vitamin A, thiamin, ascorbic acid, vitamin D and riboflavin values of foods as recorded in the literature through to December, 1940, is that of Booher, Hartzler and Hewston (29) of the United States Department of Agriculture. Another excellent source of summarized information on the vitamin content of foods is that by Fixsen and Roscoe (66) of the Rowett Institute, Scotland. Maynard and Beeson (110) have reviewed some of the causes of variation in the vitamin content of plants grown for food.

While in general there is considerable information available on the vitamin content of fruits as grown throughout the world, ascorbic acid and particularly vitamin A values are lacking for some fruits. Again many of the analyses have been insufficient in number to establish a true mean or mode. In this connection, Sherman (143) gives ranges of vitamin values of the edible portions of a number of fresh raw foods with the statement to the effect that the ranges are those "within which it appears probable that the average when sufficiently established will be found". Literature dealing specifically with the ascorbic acid content and vitamin A value of various fruits is discussed later in this bulletin following presentation of results of the assay of each vitamin on each variety of fruit.

METHODS OF PROCEDURE

Selection of Fruit for Analysis

Analyses were made of the more important varieties of cherries, apricots, peaches, prunes, pears and apples grown in the Okanagan and adjacent valleys. In order to ensure that the samples analysed were representative of the fruit being sold through commercial channels, boxes ready packed for shipment were secured from commercial packing houses in the areas where each variety is exten-

sively grown. In addition, samples of each variety harvested at various stages of maturity were secured from the orchards of the Summerland Experimental Station. The samples were held under temperature and humidity conditions similar to those commonly experienced en route to market and in retail stores. Thus stone fruits were placed in cold storage at 32°F. at the Summerland Experimental Station for several days and then removed to a ripening room where the temperature ranged from 60 to 70°F. and the relative humidity was about 50 per cent. Apples and pears were mostly of medium sizes and Fancy grade and were held at 32°F. storage, samples being removed to the ripening room at 65 to 70°F. and relative humidity 80 per cent for examination and analysis. The analyses were made after the fruit had ripened to good eating condition. During the first year's work, analyses were made also of stone fruits immediately after receipt from packing houses. These analyses were discontinued as they did not represent the fruit as received by the consumer. Furthermore it was found that while there were marked physical changes during storage and ripening there were no significant chemical changes in the proximate constituents, loss of moisture being of greatest importance.

Fig. 2. A view in the analytical section of the Fruit and Vegetable Products Laboratory.

The procedure followed ensured that the analytical data revealed the composition of the fruit at the time it would normally reach the consumer's table. It also made possible the accumulation of a great deal of information regarding the relationship between maturity at harvest time, development of quality, storage behaviour and chemical composition.

Methods of Analysis

Preparation of Samples.—The samples of fruit for chemical analysis were prepared as for consumption. Cherries were stemmed and pitted; plums, prunes

and apricots pitted; peaches peeled and pitted; apples and pears peeled and cored. Apples were peeled and cored mechanically and pears by hand. Record was kept of the weights of the edible and discarded portions (refuse). Since this was graded fruit for the fresh market, "refuse" as determined in this investigation does not include discarded fruit or pieces unavoidably lost in preparation as would occur under commercial processing conditions. Neither does it show the marked increase in percentage refuse, caused by small sizes or misshapen fruit. Hence the figures in most instances tend to be low. Further reference is made to this in the presentation of results of the analyses of each fruit.

The edible portion of the fruit was analysed for the following constituents: water, total solids, soluble solids, solids insoluble in water, acid, pH, total sugar, reducing sugar, sucrose, pectin, tannin, ash, alkalinity of ash, ascorbic acid and carotene (vitamin A).

Determination of Proximate Composition.—For determination of all constituents (proximate composition) other than vitamins, approximately 1,000 grams (2·25 pounds) of representative sample of the edible portion of the fruit was thoroughly macerated in a Waring blendor. Weighed aliquots then were taken for analysis. Methods of analysis were, with the few modifications noted below, according to the Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists (A.O.A.C.), 1940, (8). Where determinations of reducing sugars were made, the sample was neutralized with sodium hydroxide prior to extraction to prevent inversion of sucrose. The Lane and Eynon volumetric method (8, 95) for estimating sugars was employed. Total acid was determined electrometrically with a glass electrode Beckman pH meter according to the method of Bollinger (27). Acids were calculated according to which one was considered to predominate in each fruit. Citric acid was calculated as anhydrous citric acid. Tannin was estimated according to the procedure of Hartmann (77). Pectin was determined as calcium pectate according to a modification of the Carré and Haynes method employed by the Division of Chemistry, Department of Agriculture, Ottawa (86). For comparative purposes, some determinations for pectin were carried out according to the A.O.A.C. alcohol precipitate method. Slightly higher and less consistent results usually were obtained by the A.O.A.C. method. Alkalinity of ash was determined according to the A.O.A.C. method, the results being recorded as the number of millilitres of 0·1 normal acid required to neutralize the ash of 100 grams of fresh edible material. The soluble solids by refractometer were determined on the blended material employing a Zeiss industrial model refractometer, graduated with a sugar scale standardized at 20°C.

Determination of Ascorbic Acid.—Ascorbic acid (vitamin C) was determined on separate representative samples. Fruits were prepared for analysis as previously described except apples with which analyses were performed on both peeled and unpeeled cored fruit. Unless otherwise noted the ascorbic acid data presented on apples are for the unpeeled fruit. Portions for analysis were immersed immediately in acid extracting medium to prevent loss of ascorbic acid. At first 300-gram portions of edible fruit were employed. However, 150-gram samples were found to be satisfactory, this amount being used throughout most of the work. In the case of large fruits such as peaches, apples and pears, at least ten fruits from any one lot were selected for analysis. Opposite eighths were taken to make up the 150-gram sample which was macerated in 400 millilitres of 5 per cent metaphosphoric acid or 0·4 per cent oxalic acid in a Waring blendor. Oxalic acid was used as the extractant (4) for the fruits where tests showed it to give concordant results with the more commonly used metaphosphoric acid medium. After making up to definite dilution by weight, usually 1,000 grams, mixing and filtering, suitable aliquots were titrated with sodium 2,6-indophenol dye. Where there was no serious colour interference the end point was determined visually using a white background and fluorescent

daylight lamp employing the technique of Bessey and King (22). A 5- to 10-second end point was taken. Where there was colour interference, the aliquot was buffered to pH 3·5 and determined photometrically in a Klett-Summerson photoelectric colorimeter similarly to the technique described by Bessey (21). In 1947 the colorimetric method used on cherries was modified to permit more rapid analysis. The method adopted was a combination of that of Evelyn, Malloy and Rosen (60) and Loeffler and Ponting (96).

Determination of Carotene.—Carotene was determined chromatographically as beta-carotene. The fruit was prepared similarly to that previously described except that apples and pears were cored but not peeled. Representative samples of fruit, 300 grams or more of the edible portion, were placed in a Waring blendor for not more than 30 seconds to thoroughly macerate and mix the sample. Five- or ten-gram aliquots, depending upon the carotene content, were blended for 5 minutes in alcoholic potash and extracted cold according to the method for fresh materials adopted by the A.O.A.C. (8, 11). The adsorption column proposed by Wall and Kelly (164) employing the use of three parts Celite and one part magnesium oxide was found to be the most satisfactory for chromatographic separation of the extracts under study and hence was used throughout this investigation in preference to the columns suggested by the A.O.A.C. Celite No. 503 was used. The extract was concentrated to 15 to 20 millilitres in vacuo and the separation of the carotene fractions carried out according to the A.O.A.C. abridged chromatographic method (10). The carotene bands were eluted with 3 per cent and 10 per cent acetone in petroleum ether (15, 164), collected and determined in a Klett-Summerson photoelectric colorimeter using a combination of Corning filters No. 035 and No. 554. The instrument was previously standardized against solutions of purified beta-carotene (9).

As a check on the accuracy of the separation and estimation in the colorimeter, a few determinations were made employing a Beckman quartz spectrophotometer. These spectrophotometric determinations were very kindly made by Dr. Lyle A. Swain of the Pacific Fisheries Experimental Station, Vancouver, B.C., the interpretations being those of the authors.

Method of Presentation of Results.—For the sake of clarity in presentation, the results of the analyses are grouped into three parts. One section deals with the proximate composition, that is, all important constituents or groups of consituents determined, other than ascorbic acid (vitamin C) and carotene (vitamin A value). The other two sections present the results of the vitamin assays. All constituents other than vitamins are reported as a percentage by weight of the fresh edible portion. Ascorbic acid is reported as milligrams (mg.) of ascorbic acid and carotene as micrograms (mcg.) or International Units (I.U.) per 100 grams ($3\frac{1}{2}$ ounces) of fresh edible portion.

PROXIMATE COMPOSITION OF BRITISH COLUMBIA TREE FRUITS

The results of the many hundreds of analyses made over a three-year period (1943 to 1945) have been summarized in tables for each kind of fruit. These results also are discussed in detail. The figures in the tables indicate the average, maximum and minimum percentage of each constituent in the edible portion of the fruit. The tables also indicate the number of samples analysed for each constituent. In most cases, there were sufficient samples so that the figures give a good indication of the range of composition which may be expected in fruits of various kinds grown in British Columbia. The water content of the fruit is not given in the tables but may be calculated readily by subtracting the total solids figure from 100. Likewise, the water-soluble solids as determined by difference (A.O.A.C.) may be obtained by subtracting the water-insoluble solids from the corresponding figures for total solids.

Apples—Summer and Early Fall Varieties

The analytical results for apples are presented in two parts. One section deals with the summer and early fall varieties while the other covers the late fall and winter varieties. This is necessary not only because of the difference in commercial importance, but also because of the marked difference in physical and chemical characteristics.

Several summer and early fall varieties of apples, namely, Astrachan, Yellow Transparent, Duchess and Wealthy, were analysed for proximate composition. Only average values are given as insufficient replicate lots were examined to present minimum and maximum values. However, the data presented in Table 1 may be taken as indicative of their chemical composition.

Total refuse, including both peel and core, was highest in the Astrachan sample and lowest in the sample of Duchess. The values are 34·2 and 25·6 per cent respectively. The refuse was composed of about 50 per cent peel and 50 per cent core. Duchess was lowest in sugar and highest in acid content with values of 8·23 per cent and 1·62 per cent respectively. Duchess also had a high insoluble-solids content. Wealthy showed the highest sugar content, containing 9·85 per cent, and was lowest in acid at 0·84 per cent. The insoluble-solids content of Wealthy and Yellow Transparent was similar to that of winter varieties while Duchess and Astrachan had values greater than the maximum for fall and winter varieties. The pH values for these varieties are relatively low at approximately 3·0 indicating a high concentration of active acidity.

Wealthy analysed 0·60 per cent for pectin and 0·023 for tannin. The Duchess sample contained 0·76 per cent pectin and 0·047 per cent tannin. The pectin content of the Yellow Transparent sample was 0·61 per cent. Early varieties of apples are equal in pectin content to any of the winter varieties.

The most outstanding characteristic of summer apples in their proximate composition is their very high acid content which is two or more times that of winter varieties. The pH value is markedly low.

Discussion. Since only a relatively few lots of summer and early fall apples were analysed during this investigation, no detailed comparison with the limited reports in the literature seems warranted. The results appear to be in general agreement with previously published data (37, 45, 59).

Apples—Late Fall and Winter Varieties

Eighty-six samples of late fall and winter varieties of apples were analysed. These analyses included the following varieties: Delicious, Golden Delicious, Jonathan, Jubilee, McIntosh, Newtown, Rome Beauty, Spartan, Stayman, Winesap, Canada Baldwin, Golden Russet, No. 5-4, Northern Spy, N.W. Greening, Spitzenberg, Stirling, Wagener and Winter Banana. In Table 2 are reported the analytical results for all proximate constituents determined.

The average refuse as determined on 58 samples was 25·4 per cent with a minimum of 19·2 and a maximum of 36·1 per cent. The refuse was made up of approximately 49 per cent peel and 51 per cent cores. The averages for Delicious, McIntosh and Newtown varieties did not deviate markedly from this mean value. One of the chief factors determining percentage refuse in apples is size. Samples containing small sizes will average higher in total refuse than lots comprised of large fruit. Consequently it should be realized that average refuse values are reliable only when obtained from a considerable number of representative samples. For this reason, results reported for varieties containing only one or two samples are only indicative. Furthermore the refuse figures could only be used as an approximate guide in the processing industries. As the fruit used in these analyses was relatively good the average refuse value for a variety tends to be a minimum one.

TABLE 1.—PROXIMATE COMPOSITION OF COMMERCIAL SUMMER AND EARLY FALL VARIETIES OF APPLES
(SEASONS 1945–46 INCLUSIVE)

Variety[1]	Total refuse	Constituents as per cent by weight of fresh edible portion											
		Total solids	Soluble solids[2]	Water-insoluble solids	pH	Total acid[3]	Sugar as invert			Ash	Alkalinity of ash[4]	Tannin	Pectin as calcium pectate
							Total	Reducing	Sucrose				
	%	%	%	%		%	%	%	%	%		%	%
Astrachan	34·2	13·10	11·6	1·80	2·95	0·91	9·77	—	—	—	—	—	—
Yellow Transparent	31·3	13·53	11·9	1·13	3·01	1·23	8·99	—	—	—	—	—	0·61
Duchess	25·6	15·03	11·3	2·00	2·99	1·62	8·23	—	—	—	—	0·047	0·76
Wealthy	27·4	13·20	11·9	1·25	3·10	0·84	9·85	8·06	1·72	0·20	24	0·023	0·60

[1] Varieties arranged in order of harvesting; Wealthy is an early fall variety, the others summer.
[2] By refractometer at 20°C.
[3] Calculated as malic acid.
[4] Millilitres of 0·1 Normal acid required to neutralize the ash from 100 grams of fresh material.

The average sugar content for all varieties analysed was 11·64 per cent. Delicious, Jonathan, Newtown, Northern Spy, Rome Beauty, Spartan, Stayman, Winter Banana, Stirling, and No. 5-4, all averaged close to this figure. McIntosh had the lowest average sugar content of the commercial varieties with a value of 10·89 per cent. Winesap, Golden Delicious, Jubilee and Spitzenberg averaged approximately 1 per cent higher than the mean of all varieties. The maximum value for sugar in the varieties analysed was 14·02 found in Jubilee while the minimum value, 9·6, was found in McIntosh. Of the standard commercial varieties, McIntosh showed the greatest range in sugar content, a difference of 3·57 per cent between minimum and maximum, while Newtown had the least variation with a difference of 0·53 per cent. Fancy grade fruit tended to be higher in sugar than Cee grade. The late winter varieties of apples were all much higher in sugar and markedly lower in acid at eating ripeness than the summer and early fall apples. Sugar was found to comprise around 85 per cent of the soluble solids of apples.

Fig. 3. The original Spartan apple tree at 18 years of age. This introduction of the Summerland Experimental Station has good tree and fruit characteristics. It promises to become an important commercial variety.

The mean acid content of the winter varieties was 0·48 per cent with a minimum value of 0·20 per cent and a maximum of 0·86 per cent. With the exception of Delicious and Golden Delicious, the other chief commercial varieties, Jonathan, McIntosh, Stayman, Newtown and Winesap ranged in average acid content between 0·50 and 0·65 per cent. Delicious and Spartan were outstandingly low in acid content having, on the average, only a little more than half the acid of most of the other varieties.

The pH values for late fall and winter apple varieties ranged from 3·15 to 4·08 with an average of 3·46. Jonathan, McIntosh, Newtown, Northern Spy and Stayman, averaged about 0·1 pH lower than the all-variety average. Delicious had the highest average pH figure of 3·90 followed by Spartan with 3·81 and Golden Delicious with 3·59. All other varieties had average pH values between 3·39 and 3·55. Differences between minimum and maximum values for any one variety never exceeded 0·33.

There was nothing outstanding in the values found for water-insoluble solids, the average figure for all varieties being fairly constant at around 1·33 per cent. Of the commercial varieties, only Newtown and Winesap had a greater average insoluble-solids content at 1·49 per cent.

TABLE 2.—PROXIMATE COMPOSITION OF COMMERCIAL LATE FALL AND WINTER VARIETIES OF APPLES
(SEASONS 1943–45 INCLUSIVE)

Variety[1]	Total refuse	Constituents as per cent by weight of fresh edible portion											
		Total solids	Soluble solids[2]	Water-insoluble solids	pH	Total acid[3]	Sugar as invert			Ash	Alkalinity of ash[4]	Tannin	Pectin as calcium pectate
							Total	Reducing	Sucrose				
	%	%	%	%		%	%	%	%	%		%	%
All varieties—													
Average	25·4	14·92	13·7	1·33	3·46	0·48	11·64	8·37	3·06	0·21	31	0·034	0·55
Maximum	36·1	18·39	17·2	1·76	4·08	0·86	14·02	10·67	6·64	0·30	42	0·081	0·75
Minimum	19·2	12·07	11·8	0·92	3·15	0·20	9·60	6·33	1·28	0·13	18	0·013	0·36
Number of samples	58	86	67	63	86	86	86	53	53	59	46	32	50
PRINCIPAL COMMERCIAL VARIETIES													
Delicious													
Average	24·4	14·85	13·2	1·33	3·90	0·27	11·79	8·81	2·89	0·21	33	0·026	0·42
Maximum	28·5	16·35	13·9	1·76	4·08	0·58	12·65	10·13	3·52	0·27	39	0·033	0·51
Minimum	21·4	13·73	12·3	1·08	3·78	0·20	10·92	8·28	2·10	0·16	28	0·021	0·36
Number of samples	15	19	14	11	19	19	19	10	10	10	9	5	12
Golden Delicious													
Average	29·2	15·69	14·3	1·36	3·59	0·41	12·39	7·86	3·78	0·22	33	0·028	0·64
Maximum	36·1	17·05	15·7	1·61	3·72	0·51	13·31	7·97	5·34	0·27	36	0·036	0·68
Minimum	22·3	14·60	13·2	1·23	3·48	0·32	11·60	7·75	2·21	0·17	31	0·024	0·61
Number of samples	2	4	4	3	4	4	4	2	2	2	2	3	3
Jonathan													
Average	29·0	14·90	13·6	1·29	3·33	0·64	11·45	8·29	2·97	0·21	33	0·023	0·59
Maximum	31·1	16·20	14·9	1·41	3·40	0·74	12·33	8·91	3·49	0·28	41	0·033	0·68
Minimum	22·4	13·22	11·9	1·13	3·27	0·48	10·46	7·97	2·36	0·14	23	0·013	0·53
Number of samples	7	9	7	6	9	9	9	7	7	7	7	5	5
Jubilee													
Average	26·6	16·07	14·9	1·39	3·52	0·40	12·60	8·02	3·90	0·20	—	0·034	0·61
Maximum	27·9	18·24	17·2	1·58	3·64	0·49	14·02	8·26	3·90	0·23	—	—	0·75
Minimum	25·2	14·22	13·2	1·22	3·41	0·34	11·57	7·78	3·89	0·17	—	—	0·53
Number of samples	2	3	3	3	3	3	3	2	2	3	—	1	3
McIntosh													
Average	25·2	13·90	12·7	1·30	3·34	0·54	10·89	8·30	2·61	0·19	27	0·038	0·52
Maximum	29·3	17·34	15·6	1·61	3·51	0·74	13·17	10·15	3·61	0·30	39	0·063	0·63
Minimum	21·6	12·07	11·8	1·04	3·18	0·33	9·60	7·22	1·47	0·13	18	0·014	0·46
Number of samples	18	22	10	15	22	22	22	16	16	15	14	7	9

Newtown													
Average	23·4	15·44	13·8	1·49	3·30	0·61	11·67	7·50	4·18	0·19	28	0·017	0·60
Maximum	26·5	15·64	14·2	1·65	3·46	0·68	11·99	7·82	4·37	0·22	38	—	—
Minimum	20·4	15·19	12·8	1·31	3·15	0·50	11·46	7·09	3·88	0·16	24	—	—
Number of samples	4	5	5	4	5	5	5	4	4	4	4	4	1
Rome Beauty	—	15·23	13·6	1·31	3·40	0·55	11·54	—	—	—	—	0·041	0·42
Spartan													
Average	26·7	13·95	13·1	1·31	3·81	0·30	11·32	9·00	1·95	0·23	—	0·020	0·54
Maximum	30·4	15·40	13·9	1·45	3·98	0·42	12·40	9·24	2·77	0·24	—	—	0·69
Minimum	24·3	12·22	12·4	1·12	3·68	0·20	10·52	8·87	1·28	0·19	—	—	0·42
Number of samples	3	4	4	4	4	4	4	3	3	4	—	1	4
Stayman													
Average	19·2	15·23	13·8	1·23	3·37	0·59	11·69	7·05	5·02	0·29	36	0·024	0·61
Maximum	—	16·01	14·3	1·46	3·42	0·62	12·07	—	—	—	—	—	—
Minimum	—	14·62	12·9	0·92	3·30	0·52	11·17	—	—	—	—	—	—
Number of samples	1	3	3	3	3	3	3	1	1	1	1	1	1
Winesap	22·4	16·47	14·8	1·49	3·47	0·58	12·82	10·67	3·14	0·28	35	0·027	0·75
MISCELLANEOUS VARIETIES													
Canada Baldwin	—	18·39	16·4	—	3·36	0·77	13·52	6·88	6·64	0·26	42	—	—
Golden Russet	—	17·25	15·8	—	3·54	0·63	13·34	10·18	3·16	0·22	37	—	—
No. 5-4	—	14·86	13·3	1·23	3·33	0·47	11·99	—	—	0·18	—	0·019	0·59
Northern Spy													
Average	20·4	15·92	14·3	1·45	3·37	0·69	12·05	9·15	2·96	0·22	38	0·047	0·63
Maximum	24·9	16·03	14·6	1·64	3·42	0·86	12·23	9·56	3·24	0·25	40	—	—
Minimum	23·7	15·87	14·0	1·17	3·29	0·54	11·93	8·74	2·67	0·18	36	—	—
Number of samples	2	3	3	3	3	3	3	2	2	2	2	1	1
N.W. Greening	—	14·94	13·2	—	3·38	0·61	10·62	9·05	1·57	0·24	37	—	—
Spitzenberg	—	16·70	15·4	1·34	3·41	0·66	12·78	—	—	—	—	0·041	0·66
Stirling													
Average	29·8	15·61	14·0	1·40	3·39	0·45	11·98	7·94	3·16	0·18	—	0·028	0·60
Maximum	—	17·14	15·1	1·52	3·59	0·63	12·86	—	—	0·20	—	—	0·65
Minimum	—	14·07	12·8	1·28	3·26	0·27	11·10	—	—	0·15	—	—	0·54
Number of samples	1	2	2	2	2	2	2	1	1	2	—	1	2
Wagener	25·4	13·60	12·2	1·16	3·46	0·49	10·62	6·33	3·92	0·14	23	0·026	0·66
Winter Banana	—	14·70	13·4	1·41	3·51	0·43	11·41	—	—	—	—	0·081	0·67

[1] Varieties arranged alphabetically; Jonathan, McIntosh and Spartan are late fall varieties, the remainder are winter varieties. Jubilee and Spartan are recent introductions. [2] By refractometer at 20°C. [3] Calculated as malic acid. [4] Millilitres of 0·1 Normal acid required to neutralize the ash from 100 grams of fresh material.

The ash content of apples had a very narrow variation range of 0·13 to 0·30 per cent with an average value of 0·21. No significant difference was found between varieties. The alkalinity of ash showed a mean value of 31 with no appreciable variation in varieties. Apples and pears were found to be equivalent in these constituents. While apples have a good alkalizing value and are a source of essential minerals, they are not so rich in these respects as most of the stone fruits.

Thirty-two samples of winter apples were analysed for tannin. The values obtained ranged from 0·013 to 0·081 per cent, averaging 0·034 per cent. The maximum value was obtained on a sample of Winter Banana and the minimum on a Jonathan sample. The McIntosh variety averaged slightly higher than the mean value for all varieties. Delicious, Jonathan and Golden Delicious had similar average tannin contents which were slightly less than the over-all mean value.

Apples ranged in pectin content from a minimum of 0·36 per cent to a maximum of 0·75 per cent, averaging 0·55 per cent. The average values obtained in 1945 for the individual varieties were from 0·06 per cent to 0·25 higher, by difference, than those obtained in 1944. The greatest variation was found in Wagener. This fruit averaged 0·50 per cent in 1944 while the value obtained on the one sample analysed in 1945 was 0·75 per cent. The average values obtained for the varieties, McIntosh, Jonathan, Newtown, Stayman, Golden Delicious, Rome Beauty, Northern Spy, No. 5-4, and Stirling did not deviate from the mean by more than ±0·1 per cent. Winesap, Jubilee, Spartan, Wagener, Spitzenberg, and Winter Banana had a positive deviation from the mean of all varieties of from 0·1 per cent to 0·2 per cent. The maximum value of 0·75 per cent was obtained on a sample each of Jubilee and Winesap. Delicious had the lowest pectin content of all varieties analysed, averaging only 0·42 per cent. The majority of samples from other varieties had pectin contents between 0·50 and 0·65 per cent. Apples and pears have approximately the same pectin content and may be considered a fairly good source of this substance.

In general, season had little effect on the average proximate composition of individual varieties. This result probably was due to the wide range of samples of various grades from an extensive area. Previous studies have shown that the more mature fruit carrying full characteristic skin or flesh colour for the variety usually has comparatively high sugar and low acid content and develops maximum flavour (148, 149). It is interesting to note that in chemical composition, the new introductions from the Experimental Station at Summerland, Jubilee and Spartan, appear to be equal or superior to the present same season commercial varieties. However, at the time of this investigation, fruit of these new varieties was only available from trees in the Experimental Station orchards and one commercial area in the Vernon district.

Discussion.—In general, there is considerably more information available on the proximate composition of apples than other tree fruits. However, many of these data concern physical and chemical changes related to maturation of the fruit on the tree, harvest, storage, ripening and climatic conditions. In this discussion only that information which appears pertinent and comparable is reviewed.

The average refuse value was similar to that reported for Empire and English eating varieties (100) but was twice that given by Chatfield and McLaughlin (45). These latter authors' figures for skins and cores appear to be low, particularly the minimum value cited.

Results obtained for total solids with respect to range and average value were of the same general order recorded for fall and winter apples by Chatfield and McLaughlin (45) but were 1 to 1·5 per cent lower than those given by

Browne (37) and McCance and Widdowson (100). Where it was possible to compare varieties, the figures usually were fairly similar to the limited available data (59, 119, 148). Soluble solids showed good agreement with Esselen *et al.* (59).

The total sugar range and average value found was similar to published compilations (45, 59, 100, 151). The McIntosh variety averaged about 1 per cent lower in total sugar than the average reported for three samples of Massachusetts McIntosh apples (59) but 3 per cent higher than that found by Barnes (17) in Southern Minnesota, about 1 per cent higher in 3 out of 5 years than the results obtained by Caldwell (40) in Virginia, and similar to that recorded by Magness *et al.* (102) for 2-year result of Virginia-grown McIntosh apples. The range of total sugar content found for McIntosh showed practically the same minimum value but approximately 1 per cent greater maximum value than that reported by Caldwell (40).

Minimum and maximum values for total sugar content in Jonathan were slightly higher than those reported by Neller and Overley (119) and St. John and Morris (148) for Washington-grown Jonathan. The maximum figure of 12·33 per cent was comparable to the value found by Magness *et al.* (102). The average total sugar content was about 3 per cent higher than that secured by Barnes (17) for Minnesota-grown Jonathan but was about the same as that recorded by Browne (37).

The average sugar content of Delicious was found to be higher than that reported by Caldwell (40) in a 5-year study of Virginia-grown fruit and also slightly greater than that secured in one year's results by Neller and Overley (119) but was approximately 1 per cent lower than data of Magness *et al.* (102). Newtown was slightly lower in total sugar than the figures reported by Browne (37) and Magness *et al.* (102). The value found for Winesap was similar to that given by Esselen *et al.* (59).

There was, in general, good agreement with the literature with respect to the proportion of reducing and sucrose sugars present in the different varieties of apples. Taking all varieties together, reducing sugars on the average comprised 74 per cent of the total sugar and the ratio of reducing to sucrose sugars was 3·6. The varieties, McIntosh, Delicious, Jonathan and Northern Spy, gave figures close to the average for all varieties. On the other hand, on a more limited number of samples of Newtown, Golden Delicious and Jubilee, reducing sugars appear to make up about 64 to 70 per cent of the total sugars with ratios of reducing to sucrose of 4·8 to 5·6, all calculated on average values. A few analyses of Spartan indicated that reducing sugars comprised about 83 per cent of the total sugars with a reducing to sucrose ratio of 2·2. Single analyses of Stayman and Canada Baldwin yielded approximately 50 per cent of their total sugar in the reducing form. St. John and Fallscheer (147) found the ratio of levulose to dextrose in the reducing-sugar portion in Jonathan and Delicious apples to vary with variety and conditions but usually the amount of levulose present was 2 to 4 times that of dextrose. They also reported that levulose generally constituted about 55 per cent of the total sugars in these two varieties. Other workers (167) also have shown the predominance of levulose over dextrose in the reducing-sugar fraction.

The total acid content of late fall and winter varieties showed a narrower range but similar average value to that reported by Chatfield and McLaughlin (45) for these apples in the United States. Where individual varieties could be compared, the acid content of the British Columbia fruit fell within the ranges reported by other investigators for similar fruit. The average acid content tended to be slightly higher than in corresponding varieties from warmer climatic apple growing areas. However, this slightly higher acid content with the sugar and moderate tannin found in British Columbia apples results in a sprightly tasting fruit.

The range in pH values obtained for fall and winter apples was in general accord with available published data (36, 71, 130). Goldmann (71) reported a maximum pH of 5·0 as compared with a maximum figure obtained in this study of pH 4·08 for Delicious. However, she found that 75 per cent of the samples came into the pH range 3·2 to 3·5. This is in agreement with the writers' results for all varieties except Delicious and Golden Delicious which had higher pH values, particularly the former variety. The high pH value (low hydrogen ion concentration or active acidity) of Delicious apples is generally known. Insufficient data were available in the literature on similar varieties to make satisfactory varietal comparisons.

Fig. 4. All fruits after harvest receive special attention to maintain good condition, quality and nutritive value.

The results of the ash analyses were in general agreement with the literature. Also, alkalinity of ash values agreed with those of other investigators (81, 100, 167).

Because various investigators used different methods of estimating tannin and made many of the analyses on the expressed juice, it is impossible to make accurate comparisons with most of the published data. It would appear, however, that the tannin content for the same varieties of apples was of the same general order as that indicated in the literature.

The methods used by other workers for determining pectin varied widely leaving only a limited number of references presenting comparable data. The information on pectin is scattered through the literature and difficult to locate. In most cases the pectin analyses have been performed in the course of studying the pectic changes occurring in apples during growth, harvesting, storage or ripening. Several investigators determined soluble pectin on the expressed juice but this method appears to yield lower results than the A.O.A.C. boiling water extraction procedure employed by the writers. Browne (37) reported an average pectin content for apples of 0·4 per cent for representative types of American apples which included 5 summer, 2 autumn and 18 winter varieties. Several authors also have indicated seasonal maturity, and varietal differences in pectin

content. Esselen *et al.* (59) stated that the pectin content of fresh apples averages about 0·5 per cent which figure agrees closely with the average value of 0·55 per cent obtained for late fall and winter apples in this investigation.

Apricots

The fruits of 75 samples of the following varieties of apricots were analysed; Wenatchee Moorpark, Blenheim (Royal), and Tilton. The results of the analyses for the three seasons are summarized in Table 3.

Refuse determinations were made on 48 samples of the different apricot varieties. The average figure obtained for all varieties analysed was 8·1 with a minimum of 5·9 per cent and a maximum of 11·1 per cent. The mean value for each variety was very close to the average of all varieties with the Tilton variety showing the highest average of 8·5 per cent and Blenheim the lowest with 7·9 per cent. Variation within varieties, however, was quite large as indicated by the range between minimum and maximum figures. In apricots, refuse represents primarily the pits or stones which comprise a greater percentage by weight in immature fruits than they do in fruits more fully ripened on the trees. This observation applies in general to all stone fruit although in peaches the usual practice of peeling adds another significant factor.

The average sugar content for the 3-year period was 7·41 per cent, ranging from a minimum of 3·9 per cent to a maximum of 10·7 per cent. In 1943 the average sugar content of apricots was 0·5 per cent higher than in 1944 and 0·2 per cent higher than in 1945.

The slightly higher sugar content of the 1943 apricots may be partly accounted for by the fact that several lots of prime canning maturity apricots harvested on the Experimental Station orchards were included in the analyses. Apricots of good canning maturity had a significantly greater sugar content of about 2 per cent on the average. In the figures presented in Table 3, fruit of canning maturity would fall largely into the range between the average and maximum values, while most of the fruit being shipped to the fresh market would fall in the range between the average and minimum values.

There was some variation between apricot varieties in average sugar content. Blenheim averaged the highest with 8·58 per cent. Tilton was next with 7·45 per cent. Wenatchee Moorpark averaged the lowest with only 6·61 per cent sugar. This latter variety was consistently lower in sugar and higher in acid than the other varieties. There was great variation in sugar content within a variety as indicated by the minimum and maximum values in Table 3. Tilton showed the least variation in sugar content.

The sugar in apricots consists of approximately 75 per cent sucrose and 25 per cent reducing sugars. As with other stone fruits, good quality in apricots is correlated with sugar and acid content. There is no increase in sugar after the fruit is harvested. This was found to be true for all stone fruits. Thus while stone fruits improve in colour and certain desirable physical changes generally take place, the eating quality is determined largely by the content of sugar and acid at the time the fruit is picked. For fresh market shipment, apricots containing 6 per cent or more sugar and having a sugar-acid ratio of 4:1 or greater, are of good quality. Fruit containing a lower percentage of sugar as compared with acid usually did not develop good colour and tended to be flat or astringent. Analyses showed the soluble-solids content of apricots to be approximately 60 per cent sugar. Thus, fruit containing 6 per cent actual sugar had a refractometer reading of 10 per cent. The other factors affecting refractometer readings for soluble solids remain fairly constant while sugar content changes the most during maturation. This change is reflected directly in the refractometer reading of the soluble solids.

The acid content of apricots ranged from 0·86 to 1·96 per cent, averaging 1·36 per cent. Wenatchee Moorpark, with an average value of 1·49 per cent contained more acid than the other varieties. Blenheim was lowest with 1·19 per cent acid. There was more variation in acid content due to different maturities than to variety or season. It was noted also that fruits picked for fresh market shipment contained more acid and less sugar than did those harvested at the canning ripe stage.

Apricots showed a mean ash content of 0·64 per cent with a maximum of 0·90 and a minimum of 0·50 per cent of the varieties tested. Wenatchee Moorpark contained the greatest quantity of minerals with an average ash content of 0·72 per cent. This variety also showed the greatest range in percentage ash varying from 0·61 to 0·90 per cent. There was no significant difference in ash content between the other varieties and their range of variation was very narrow. Besides having a very good ash content indicating that apricots are one of the best fruit sources for minerals, they also were found to have a potentially high alkalizing value. This latter property is indicated by the average alkalinity of ash value of 89 with minimum and maximum values of 75 and 115 respectively.

The water-insoluble-solids content of all varieties analysed ranged from 1·03 to 1·98 with an average value of 1·59 per cent. The mean value for insoluble solids in the three varieties varied little from the all-variety average. The variation in insoluble-solids content was greatest in Wenatchee Moorpark ranging from 1·03 to 1·97 per cent.

The pH value of apricots varied from 3·39 to 4·55 with an average of 3·78. A few lots of each variety showed pH falling between 4·3 and 4·5. These are relatively high pH values especially in view of the fact that the total acid was never found to be less than 0·86 per cent and usually considerably more. Such values are in all probability due to relatively large amounts of buffering salts present in the fruit as indicated by high ash content and potential alkalinity. One lot of Blenheim had a pH of 4·55. Of the varieties tested, Wenatchee Moorpark showed the lowest average pH value of 3·68, which is in agreement with this variety's greater average total acid content. Blenheim apricots were the least acid of the varieties with the highest average pH value of 3·90 and the lowest total acid value of 1·19 per cent. Tilton showed values approximately midway between Wenatchee Moorpark and Blenheim.

The average tannin content for all varieties at the eating ripe stage was 0·042 per cent with a minimum of 0·019 and a maximum of 0·084 per cent. The Blenheim variety averaging 0·051 per cent was generally slightly richer in tannin than the other two varieties. The variation in tannin content within varieties was greater than that between varieties. Blenheim showed the greatest variation ranging from 0·025 per cent to 0·084 per cent.

Apricots proved to be a rich source of pectin, analysing higher for that constituent than any other fruit employed in this study. The pectin content for all varieties ranged from a minimum of 0·68 per cent to a maximum of 1·18 per cent, with an average value of 0·98 per cent. The minimum value of 0·68 per cent still represents a fairly good pectin content. It can be seen from Table 3 that varietal differences were slight and the variation was similar in all varieties.

Discussion.—Information is lacking in the literature on the proximate composition of different varieties of apricots. Values obtained for refuse and total solids in this study are in general agreement with the reports in the literature for apricots (45, 100). No comparative data on soluble solids and water-insoluble solids other than earlier work by two of the authors (12), were found except the very limited analyses of Olig (124) in Europe, whose results were of the same order.

The total sugar content for all varieties averaged almost 3 per cent lower than that reported by Chatfield and McLaughlin (45), about 1 per cent higher

TABLE 3.—PROXIMATE COMPOSITION OF COMMERCIAL APRICOTS (SEASONS 1943–45 INCLUSIVE)

Variety[1]	Total refuse	Constituents as per cent by weight of fresh edible portion											
		Total solids	Soluble solids[2]	Water-insoluble solids	pH	Total acid[3]	Sugar as invert			Ash	Alkalinity of ash[4]	Tannin	Pectin as calcium pectate
							Total	Reducing	Sucrose				
	%	%	%	%		%	%	%	%	%		%	%
All varieties													
Average	8·1	13·27	11·7	1·59	3·78	1·36	7·41	1·87	5·60	0·64	89	0·042	0·98
Maximum	11·1	16·54	15·2	1·98	4·55	1·96	10·70	2·71	7·67	0·90	115	0·084	1·18
Minimum	5·9	9·57	8·0	1·03	3·39	0·86	3·90	1·17	2·73	0·50	75	0·019	0·68
Number of samples	48	75	44	35	54	54	75	25	25	26	26	14	37
Wenatchee Moorpark													
Average	8·1	12·42	11·1	1·55	3·68	1·49	6·61	1·55	4·60	0·72	92	0·040	1·02
Maximum	10·5	15·57	13·6	1·97	4·33	1·96	9·01	1·89	6·32	0·90	115	0·064	1·15
Minimum	6·1	9·57	8·0	1·03	3·42	1·03	3·90	1·17	2·73	0·61	77	0·019	0·80
Number of samples	23	36	25	14	24	24	36	7	7	8	8	7	19
Blenheim (Royal)													
Average	7·9	14·63	13·3	1·67	3·90	1·19	8·58	2·14	6·37	0·63	90	0·051	0·90
Maximum	11·1	16·54	15·2	1·98	4·55	1·54	10·70	2·71	7·67	0·69	103	0·084	1·00
Minimum	5·9	11·62	10·6	1·49	3·52	0·94	5·31	1·54	4·56	0·55	81	0·025	0·75
Number of samples	15	24	12	13	18	18	24	10	10	11	11	4	11
Tilton													
Average	8·5	13·18	11·6	1·53	3·84	1·39	7·45	1·83	5·51	0·57	83	0·036	0·98
Maximum	10·2	14·28	13·1	1·79	4·41	1·59	8·58	2·40	6·23	0·63	90	0·042	1·18
Minimum	7·1	11·50	10·3	1·29	3·53	0·86	6·37	1·56	4·91	0·50	75	0·029	0·68
Number of samples	10	15	7	8	12	12	15	8	8	7	7	3	7

[1] Varieties are listed in order of ripening.
[2] By refractometer at 20°C.
[3] Calculated as malic acid.
[4] Millilitres of 0·1 Normal acid required to neutralize the ash from 100 grams of fresh material.

than that by McCance and Widdowson (100), and, in the case of Blenheim, 1 to 3 per cent lower than previously reported from this Laboratory (12). The average total, reducing and sucrose sugar obtained in this study for Blenheim apricots was similar to that found by Allen (2) in California. Because the sugar content of apricots varies markedly with harvest maturity, season and variety, it is difficult to make comparisons with other areas, particularly when varieties are not indicated. As at present harvested for the fresh market, Wenatchee Moorpark proved to be lower in sugar content by about 1 to 2 per cent than the other commercial varieties.

Total acid tended to be slightly higher than that reported by Chatfield and McLaughlin (45) but lower than Olig (124). The range, however, was of the general order of that given by other investigators (2, 45).

The ash content was practically the same as that reported by others (45, 167). Average value for alkaline ash was almost identical to that found by McCance and Widdowson (100), slightly higher than Olig (124), and about 0·35 per cent greater than Heinz (81).

No pertinent data were available for comparison of tannin and pectin content for apricots from other areas or countries.

Cherries

Fifty-seven samples of cherries secured throughout the commercial producing area were analysed for proximate composition. The varieties analysed were as follows: Bing, Lambert, Royal Ann and Deacon. The results of the analyses for all constituents are presented in Table 4. Only limited analyses were made of Royal Ann and Deacon. The Deacon variety is used largely as a pollenizer and likely will be superseded in the next five years by a superior quality pollenizing variety such as the new introduction called "Van".

Determination of the inedible portion, or refuse, was made on 17 samples of sweet cherries. The average for all varieties was 11·0 per cent, consisting of 10·0 per cent pits and 1·0 per cent stems. The Bing variety was consistently 3 per cent lower in refuse content than Lambert or Royal Ann. The latter varieties had approximately the same percentage of refuse. Extensive observations showed that sound, fully matured cherries were of better quality and less susceptible to shrivelling during storage than were immature fruits. They also contained at the end of the storage period a larger percentage of edible fruit with correspondingly less waste to the consumer.

As indicated in Table 4, no very marked variation was found in the average chemical composition, either within or between varieties. Total solids and sugar content showed the greatest variation. This variation was associated with harvesting maturity. Generally, samples with a high total solids content also analysed high for the other constituents.

The sugar content for all varieties for 1943-45 ranged from 9·71 per cent to 17·54 per cent with an average of 13·60 per cent. Bing cherries with an average sugar content of 14·13 per cent showed 2 per cent more total sugar than did the Lambert or Royal Ann varieties. These latter varieties showed corresponding values of 12·65 and 12·84 per cent respectively. There was no marked seasonal variation during 1943-45 in the mean sugar content for any one variety of sweet cherry.

In contrast with the other stone fruits, the sugar in cherries is almost entirely the simple reducing form, analysis showing only from 0 to 0·6 per cent sucrose to be present in the fruit. This fruit attains its maximum quality on the tree and there is no significant increase in sugar or acid after picking. Any apparent increase is due to moisture loss during storage. On the whole, there exists a close relationship between quality and total sugar. Bing cherries containing 14 per cent, Lambert 13 per cent, and Royal Ann 12 per cent, all tended

TABLE 4.—PROXIMATE COMPOSITION OF COMMERCIAL CHERRIES (SEASONS 1943-45 INCLUSIVE)

Variety[1]	Total refuse	Constituents as per cent by weight of fresh edible portion											
		Total solids	Soluble solids[2]	Water-insoluble solids	pH	Total acid[3]	Sugar as invert			Ash	Alkalinity of ash[4]	Tannin	Pectin as calcium pectate
							Total	Reducing	Sucrose				
	%	%	%	%		%	%	%	%	%		%	%
All varieties													
Average	11·0	21·64	21·2	1·33	3·99	0·69	13·60	13·03	0·10	0·58	79	0·141	0·24
Maximum	16·6	27·71	26·5	1·54	4·39	0·96	17·54	17·56	0·63	0·81	92	0·176	0·41
Minimum	8·2	11·64	15·0	0·81	3·82	0·48	9·71	9·71	0·00	0·49	70	0·073	0·11
Number of samples	17	53	33	30	57	57	57	27	27	20	18	9	18
Bing													
Average	9·0	22·74	22·1	1·40	4·01	0·72	11·13	13·81	0·11	0·62	82	0·158	0·27
Maximum	10·3	27·71	26·5	1·54	4·31	0·96	17·54	17·56	0·63	0·81	92	0·176	0·41
Minimum	8·2	17·77	18·6	1·24	3·87	0·58	10·57	10·67	0·00	0·50	72	0·142	0·14
Number of samples	7	25	38	14	25	25	28	12	12	9	8	5	9
Lambert													
Average	11·9	20·01	18·8	1·27	4·00	0·65	12·65	12·34	0·06	0·55	77	0·146	0·25
Maximum	16·6	23·81	22·9	1·50	4·39	0·86	15·10	14·65	0·30	0·62	86	—	0·38
Minimum	8·8	15·81	15·0	0·81	3·82	0·48	9·26	9·71	0·09	0·49	70	—	0·11
Number of samples	8	24	11	16	23	25	25	12	12	10	9	1	5
Royal Ann[5]													
Average	12·1	20·94	20·6	—	3·94	0·68	12·84	11·29	0·10	—	—	0·079	0·20
Maximum	14·8	23·66	23·0	—	3·98	0·74	14·50	12·15	0·14	—	—	0·085	0·30
Minimum	9·4	17·35	17·2	—	3·92	0·62	10·48	10·42	0·06	—	—	0·073	0·12
Number of samples	2	4	5	—	3	3	4	2	2	—	—	2	4
Deacon[6]													
Average	—	—	—	—	3·88	0·72	—	—	—	—	—	0·174	—
Maximum	—	—	—	—	3·92	0·76	—	—	—	—	—	—	—
Minimum	—	—	—	—	3·80	0·65	—	—	—	—	—	—	—
Number of samples	—	—	—	—	4	4	—	—	—	—	—	1	—

[1] Bing and Lambert are main sweet cherry crop varieties.
[2] By refractometer at 20°C.
[3] Calculated as malic acid.
[4] Millilitres of 0·1 Normal acid required to neutralize the ash from 100 grams of fresh material.
[5] Harvested at fresh market maturity from Experimental Station orchard. No commercial lots as this fruit is at present harvested mainly for processing.
[6] Harvested at advanced maturity from Experimental Station orchards. No commercial lots.

to be good in quality while those with a lower sugar content were only fairly good to poor. Since sugar usually was found to comprise 64 per cent of the total soluble solids of cherries, the corresponding refractometer readings were as follows: Bing 21·9 per cent, Lambert 20·3 per cent and Royal Ann 18·8 per cent. Lamberts having total soluble solids readings by refractometer of 17 to 20 per cent and Bings 18 to 21 per cent, generally were preferred for market, having good bright colour and satisfactory handling and quality characteristics. On the other hand, Lambert or Bing cherries having refractometer readings of less than 17 per cent were a reddish colour and were definitely inferior in quality.

The acid in cherries ranged from a maximum of 0·96 per cent to 0·48 per cent with an average of 0·69 per cent. No significant difference in total acid was noted between varieties, although Lambert had a mean value a trifle lower than the other varieties.

Sweet cherries showed a mean ash content of 0·58 per cent with a maximum of 0·81 per cent and a minimum of 0·49 per cent. There was no significant difference in ash content between varieties. Determinations for alkalinity of ash yielded an average value of 79 with a minimum of 70 and a maximum of 92 per cent, there being again no varietal differences. Cherries are thus one of the best sources of minerals found in tree fruits and have strong potential alkalizing effect.

The pH value of cherries was found to be fairly constant throughout the three seasons for all the sweet varieties analysed ranging from 3·82 to 4·39 with an average value of 4·01. The great majority of the samples fell between 3·9 and 4·1. Royal Ann and Deacon showed a very narrow range in pH with a difference of only about 0·1 between minimum and maximum readings. Deacon had the lowest average pH value of 3·88. However, the sampling number of these two varieties was very small and the fruit all came from the Experimental Station orchards. Bing and Lambert which were sampled on an extensive basis, proved to have very similar pH ranges (in round figures) of 3·8 to 4·4 and average value of 4·0.

Cherries were found to have an average water-insoluble-solids content of 1·33 per cent. There was no significant difference in this constituent between the varieties, Bing and Lambert.

The average tannin content for all varieties was 0·141 per cent with a minimum of 0·073 per cent and a maximum of 0·176 per cent. Bing cherries averaged highest in tannin content with 0·158 per cent while Royal Ann was lowest with an average of 0·079 per cent. The single samples of Lambert and Deacon analysed for tannin contained 0·146 per cent and 0·174 per cent respectively. The lighter coloured varieties contain less pigment and for this reason the tannin content appears lower than that of the rich maroon or black varieties. Where high tannin content is associated with high acid and low sugar, the fruit is of poor market quality.

Soluble pectin, the most important form of pectin from a dietetic and processing standpoint, was determined on 18 samples. It will be noted that cherries are low in pectin. The average composition for all varieties analysed was 0·24 per cent with a minimum of 0·11 per cent and a maximum of 0·41 per cent. Little variation was found between the 1944 and 1945 analyses. Bing cherries averaged 0·02 per cent higher than Lambert and 0·07 per cent higher than Royal Ann.

Discussion.—The refuse values for sweet cherries obtained in this investigation were similar to those reported by McCance and Widdowson (100) but on the average were almost double those given by Chatfield and McLaughlin (45). These latter figures, which are similar to the refuse values reported in the early work of Shaw in Oregon and Colby in California (167), appear to be abnormally low for fresh pitted fruit.

Total solids and total sugar averaged at least 1·5 per cent higher than that generally reported in the literature (45, 100, 167). Soluble-solids content range found for Royal Ann and Lambert varieties agreed with that reported by Hartman and Bullis (79) in an investigation of these fruits in Oregon. There is little published information on water-insoluble-solids content of cherries. Values found were approximately three-quarters those given by Olig (124) for three samples of European cherries. Good agreement was found with the literature (45, 100, 167) with respect to total acid and ash content although there was a considerably narrower range in acid content than that given by (45). The value for alkalinity of ash corresponded to that found by McCance and Widdowson (100) but on the average was one-third to two-thirds greater than that reported by others (81, 167). Perhaps some of this difference may be accounted for by difference in method of estimating potential alkalinity and by the limited number of samples analysed.

Only two references were found in the literature relative to the tannin content of sweet cherries (79, 167). There appears to be reasonable agreement but due to the difference in the methods used by these investigators in estimating tannin, accurate comparison of results with current work is impossible.

Peaches

The fruits of 106 samples of the following varieties of peaches were analysed: Fisher, Rochester, Vedette, Veteran, Valiant, J. H. Hale and Elberta. The results of analyses for the three seasons are summarized in Table 5.

Refuse determinations were made on 43 samples of peaches. The average for all varieties was found to be 13·0 per cent with maximum and minimum values of 17·8 and 10·3 per cent respectively. Deviation from this mean figure for any single variety did not exceed ± 1·0 per cent. Veteran showed the highest average refuse of 14 per cent while Valiant was lowest with 11·1 per cent. There was no apparent seasonal variation in the percentage refuse for

Fig. 5. For nutritive value and quality peaches should be picked when they are well filled out but still firm.

any one variety. Degree of maturity produced the most significant variable effect on the percentage refuse found for each variety. The refuse in peaches was composed of approximately 56 per cent pits and 44 per cent peel.

The average sugar content of all varieties was 8·96 per cent, ranging from a minimum of 6·65 to a maximum of 11·10 per cent. Over the three seasons, J. H. Hale showed consistently the highest average sugar content of 9·6 per cent with the three "V's" the lowest at 8·70 per cent. This is a fairly narrow range and it can be concluded that there is little significant difference in the sugar content of the commercial varieties of peaches as grown in British Columbia. Seasonal variations for these three years were negligible. As with apricots and cherries, harvest maturity had the greatest influence on the total solid and sugar content of peaches. Sucrose comprised 70 per cent of the sugar in peaches. The commercial packages examined in 1944 and 1945 were of more uniform maturity and on the average slightly better quality than in 1943.

Peaches of good canning maturity contained at least 1 per cent more sugar than fruit harvested for fresh fruit shipment. As pointed out in the case of apricots, the sugar content of canning maturity peaches would generally fall between the average and maximum values given in Table 5.

It is evident that fruit containing 8 per cent or more sugar, regardless of variety and having a sugar-acid ratio of at least 12:1 tended to be of good quality. On the other hand, fruit which contained less than 8 per cent sugar and had ratios of sugar to acid of much less than 12:1 was usually of poorer quality. Among the varieties, Valiant with an average sugar-acid ratio of 9·4:1 was much lower than the others. This was primarily due to the higher average acid content. However, this higher average total acid value is not considered typical of the Valiant variety for several reasons. Only eight samples were analysed for acid. Unfortunately the samples were of very limited representation. Furthermore, several previous years' experience by the writers with this variety in the processing field indicated it to be similar in proximate composition to the other two "V" varieties, Vedette and Veteran. It was found that sugar comprised about 73 per cent of the total soluble solids in peaches. Therefore fruit containing 8 per cent sugar would have a corresponding refractometer reading of 11 per cent total soluble solids.

The acid content of peaches ranged from 0·50 to 1·33 per cent with an average of 0·81 per cent for all varieties. Of the individual varieties, Valiant showed the highest average acid content with a mean value of 0·93 per cent. Rochester contained the least acid with an average value of 0·73 per cent. All the other varieties had almost identical average acid contents of close to 0·8 per cent. Thus there was no great variation in acid content between varieties. The variation due to maturity was much more marked. The total acid content was somewhat lower in 1944 than in the 1943 season. This was correlated with a slightly lower sugar content thus maintaining a fairly constant sugar-acid ratio. While varieties which were high in sugar also tended to be high in acid, it was found that within a variety the more mature harvested fruit contained more sugar and less acid than less mature fruit.

Peaches were found, from 51 analyses, to range in ash content from 0·30 per cent to 0·57 per cent with a mean value of 0·43 per cent. Elberta and J. H. Hale showed an average ash content of 0·45 and 0·49 respectively while the other varieties had about the same content at 0·40 per cent. It is seen therefore that the difference in ash content between varieties was negligible and the range of variation was relatively small. The ash content indicates that peaches are a good source of minerals from fruits. Peaches were found to have an average alkalinity of ash value of 62 with minimum and maximum values of 48 and 77 respectively. Thus, while the potential alkalizing properties of peaches are somewhat less than those of apricots and cherries, they are still good.

The water-insoluble-solids content as estimated on 38 samples ranged from 0·82 to 1·66 with an average value of 1·16 per cent. These values are somewhat lower than those recorded for apricots and cherries indicating that peaches are

lower in fibre content than these fruits. However, Elberta and J. H. Hale had average values of 1·35 and 1·38 per cent respectively which is approximately the same as that found for cherries. All the other varieties had mean values close to 1·1 per cent. Variation range within a single variety did not exceed 0·6 per cent by difference.

The pH value of peaches ranged from 3·43 to 3·96 with a mean value of 3·64. This is a relatively narrow range of variation. There was no significant difference between or within varieties. While the more mature fruit tended to have higher pH values the increase was not marked.

The tannin content for all varieties ranged from 0·013 to 0·130 per cent with an average value of 0·053 per cent. Peaches showed a much greater variation in tannin content than did apricots. Veteran and Valiant had the lowest average values at 0·028 and 0·029 per cent respectively while Vedette contained almost twice as much. J. H. Hale and Elberta were relatively high in tannin, containing about three times that of Valiant and Veteran with averages of 0·085 per cent and 0·094 per cent respectively. The high tannin content of Elberta may account in part for its somewhat astringent flavour. Also, a high tannin content together with enzyme activity is conducive to causing brown discoloration of the fruit on bruising or in preparation for processing.

Peaches contained three-quarters the amount of pectin found in apricots. They averaged 0·74 per cent pectin with a maximum value of 1·06 per cent and a minimum value of 0·55 per cent. Hence peaches are a very good source of this constituent. There was no marked difference in content between varieties. J. H. Hale and Elberta were highest with an average of 0·83 and 0·78 per cent respectively. Valiant, Vedette, Veteran and Rochester had pectin values close to the mean value for all varieties. On the whole, the range of variation within varieties was small and of the same order.

Discussion.—Results of analyses for refuse and total solids in peaches were similar to those reported in the literature (45, 75, 100, 120). The average and range of soluble solids in Elberta and J. H. Hale peaches were found to be similar to the values reported for these varieties from several peach-growing areas of the United States (2, 50, 120). No comparative data on water-insoluble-solids content of peaches were observed in the literature.

The average total sugar content for all varieties corresponded to that given in other compilations (45, 100). The range in sugar present in various varieties was found to be similar to that reported by Chatfield and McLaughlin (45) for fruit grown in the States of Georgia, North Carolina, Maryland and New Jersey. The values obtained for sugars in Elberta peaches corresponded to those reported by Neubert *et al.* (120) in Washington, and Allen (2) in California but were slightly lower than those given by some other workers (50, 75). The J. H. Hale showed a sugar content 1 to 2 per cent higher than that recorded by Neubert (120) but similar to that found by Haller (75) for unpeeled fruit. In common with other stone fruits, the sugar content and other constituents of peaches are greatly influenced by maturity at harvest, season, and storage or ripening. Effect of these factors on the composition of the flesh of peaches has been thoroughly demonstrated and discussed by Neubert *et al.* (120), and others (2, 23, 25, 53, 121). When fruits of similar harvest maturity and ripeness are compared, the results are in general agreement with data of other workers. In the last stage of ripening of Elberta and J. H. Hale peaches on the tree, Neubert and his associates (120) observed no consistent increase in sugar content, any increase being offset by the rapidly increasing size of the fruit. Reducing and sucrose sugars were of the same general order of the limited analyses available in the literature.

Total acid averaged 0·1 to 0·2 per cent higher than that recorded in the literature (23, 45, 120) with pH tending to be correspondingly lower (120). However, the pH values for Elberta and J. H. Hale agreed with those given by Haller (75) for these two varieties.

TABLE 5.—PROXIMATE COMPOSITION OF COMMERCIAL PEACHES (SEASONS 1943–45 INCLUSIVE)

Variety[1]	Total refuse	Constituents as per cent by weight of fresh edible portion											
		Total solids	Soluble solids[2]	Water-insoluble solids	pH	Total acid[3]	Sugar as invert			Ash	Alkalinity of ash[4]	Tannin	Pectin as calcium pectate
							Total	Reducing	Sucrose				
	%	%	%	%		%	%	%	%	%		%	%
All varieties													
Average	13·0	13·11	12·1	1·16	3·64	0·81	8·96	2·45	6·35	0·43	62	0·053	0·74
Maximum	17·8	16·16	14·0	1·66	3·96	1·33	11·10	3·17	7·93	0·57	77	0·130	1·06
Minimum	10·3	10·41	9·7	0·82	3·43	0·50	6·65	1·96	4·94	0·30	48	0·013	0·55
Number of samples	43	106	50	38	82	82	106	46	46	51	46	23	47
Fisher[5]	—	12·57	11·9	—	—	—	8·52	—	—	—	—	0·038	0·63
Rochester													
Average	13·5	13·13	12·1	1·06	3·65	0·73	9·03	2·20	6·49	0·40	61	0·038	0·74
Maximum	17·5	14·45	13·2	1·17	3·91	0·91	10·46	2·49	7·86	0·49	76	—	0·78
Minimum	10·3	11·69	11·0	0·95	3·50	0·63	7·60	2·05	5·14	0·30	50	—	0·68
Number of samples	10	17	7	10	16	16	17	9	9	11	11	1	7
Valiant													
Average	11·1	12·58	11·8	1·16	3·51	0·93[6]	8·71	2·17	6·41	0·42	58	0·029	0·70
Maximum	11·9	13·26	12·6	1·31	3·73	1·09	9·53	2·24	6·87	0·47	67	0·038	0·77
Minimum	10·3	11·22	11·3	1·05	3·45	0·75	7·44	2·03	5·89	0·36	50	0·019	0·60
Number of samples	4	12	6	6	8	8	12	5	5	5	4	4	6
Vedette													
Average	12·0	12·44	12·0	1·03	3·69	0·78	8·69	2·19	6·33	0·42	61	0·050	0·70
Maximum	15·5	13·61	12·9	1·18	3·89	0·95	9·97	2·37	7·60	0·48	68	0·065	0·81
Minimum	9·8	11·52	11·1	0·82	3·50	0·68	7·73	1·96	5·37	0·36	48	0·033	0·55
Number of samples	9	23	11	12	16	16	23	8	8	9	8	6	10

Veteran													
Average	14·0	12·74	11·8	1·11	3·64	0·79	8·86	2·34	6·07	0·40	56	0·028	0·70
Maximum	17·8	15·01	12·5	1·41	3·96	1·33	10·22	2·61	6·89	0·45	67	0·054	0·86
Minimum	10·8	11·24	11·0	0·85	3·45	0·53	7·71	6·89	5·23	0·35	48	0·013	0·56
Number of samples	9	19	7	14	15	15	19	9	8	9	8	4	7
J. H. Hale													
Average	12·8	14·25	12·5	1·38	3·61	0·81	9·60	3·09	6·64	0·45	65	0·085	0·83
Maximum	16·0	16·16	14·0	1·66	3·82	1·10	11·10	3·17	7·93	0·51	76	0·130	1·06
Minimum	10·7	12·27	11·4	1·16	3·43	0·50	8·20	2·03	4·94	0·36	55	0·042	0·65
Number of samples	8	17	10	7	12	12	17	7	7	8	6	5	10
Elberta													
Average	13·4	13·60	12·0	1·35	3·64	0·85	9·02	2·68	6·33	0·49	66	0·094	0·78
Maximum	16·3	15·34	13·5	1·65	3·87	1·02	10·40	3·05	7·83	0·57	77	0·094	0·86
Minimum	11·1	10·41	9·7	1·05	3·46	0·64	6·65	2·30	5·16	0·44	60	0·093	0·66
Number of samples	9	15	6	9	13	13	15	7	7	7	7	2	6

[1] Varieties arranged in order of harvesting:—Early season: Fisher, Rochester. Mid-season: Valiant, Vedette, Veteran. Late season: J. H. Hale, Elberta.
[2] By refractometer at 20°C.
[3] Calculated as malic acid.
[4] Millilitres of 0·1 Normal acid required to neutralize the ash from 100 grams of fresh material.
[5] One sample only.
[6] This average value considered atypical. Normally similar to Vedette and Veteran.

The few ash analyses available in the literature for comparison were similar to the values obtained in the present study (50, 167). The alkalinity of ash average figure was almost identical to mean values previously reported (81, 100).

With respect to tannin content, limited comparisons were possible only in the case of Veteran, Elberta and J. H. Hale. The values obtained for these varieties were in general agreement with the findings of Blake (24), Blake and Davidson (26) and Neubert *et al.* (120) for similarly ripened fruit. Hotter (84) reported on five samples of Austrian peaches which showed the following range for tannin content, 0·06 to 0·22 per cent. Varietal differences can be very marked as shown by Kertesz (89) in New York who obtained values ranging from 0·005 to 0·132 per cent, the latter figure being for Elberta. It has been indicated also that nutrition, for instance, nitrogen supply, may influence greatly the tannin content of peaches (121). Blake (24, 26) has reported on the effect of season and other factors, including inheritance, on the tannin content of peaches.

No satisfactory comparative data were found in the literature concerning soluble-pectin content of peaches. Appleman and Conrad (6) in studying pectic constituents of peaches reported a soluble-pectin content in ripe Crawford peaches of about 0·64 per cent which is just a little less than the average for most of the varieties studied in this investigation.

No published information was found on proximate composition of Fisher, Rochester, Valiant, Vedette or Veteran peaches with which the results of this study could be directly compared.

Pears

Forty-six samples of pears representing all major commercial varieties were analysed. Data on the proximate composition of pears are presented in Table 6.

Refuse was determined on 36 samples yielding an average figure of 21·5 per cent. The percentage varied from a minimum of 18·3 to a maximum of 28·5. There was no significant variation between varieties in total average refuse with the possible exception of Flemish Beauty which showed one per cent more refuse. Refuse was composed of approximately 68 per cent peel and 32 per cent core and these percentages were only slightly influenced by varietal differences. Samples of small, immature harvested fruit showed the highest percentage refuse. Waste becomes excessive with very small fruit.

The average sugar content for all varieties of pears was found to be 9·53 per cent with minimum and maximum values respectively of 7·87 and 12·61 per cent. There was no significant variation in this average figure for the three seasons. Variation in variety from season to season also was small. It will be noted, however, from Table 6, that Flemish Beauty was significantly lower in sugar content than the other varieties tested with an average of 8·36 per cent while Bosc (Beurre Bosc) was highest with an average of 11·09 per cent. The total solids also were correspondingly low and high respectively. In Anjou (Beurre d'Anjou) and Flemish Beauty, about 20 per cent of the sugar was present in the form of sucrose. In Bosc, sucrose comprised 30 per cent of the sugar and in Bartlett (Williams' Bon Chrétien) about 16 per cent. Sugar comprised almost 70 per cent of the total soluble solids in pears.

In general, pears are very low in acid, ranging for all varieties from 0·13 to 0·52 per cent with an average of 0·32 per cent. The acidity of Bartlett pears ranged from 0·25 to 0·52 per cent with an average of 0·38 per cent while Flemish had an average of 0·22 per cent with minimum and maximum values of 0·17 and 0·28 respectively. Bosc also had a low acidity similar to Flemish Beauty but more of its acid was active as indicated by the lower pH value for this variety.

The pH of pears varied from a minimum of 3·24 to a maximum of 4·48 with an average value of 3·77 being found for all varieties. Of the commercial

varieties, Bosc and Bartlett had the lowest or most acid average pH values of 3·70 and 3·73 respectively, followed by Anjou with pH 4·1. Flemish Beauty was definitely the least acid variety with the highest average pH of 4·38. Bartlett and Bosc showed the greatest range in variation for pH. For instance, Bartlett varied from 3·5 to 4·07 and Bosc 3·24 to 4·22. Flemish and Anjou had almost constant pH values, the difference between minimum and maximum values being less than 0·3. However, pH tests of different portions of pear fruits showed a marked range in pH, the epidermal layer being most acid (lowest pH) with progressively higher pH (less acid) being recorded toward the core area.

Water-insoluble-solids content of pears averaged 2·08 per cent. Bartlett showed the greatest average with 2·36 per cent and Anjou the lowest with 1·55 per cent.

There was little difference between varieties in ash content. The average alkalinity of ash was 41 being approximately the same for all varieties.

With the exception of one variety, this fruit was found to be low in tannin, ranging from a maximum of 0·058 to a minimum of 0·015 per cent, with an average for all varieties of 0·025 per cent. A sample of Winter Nelis yielded the maximum value of 0·058 per cent which was at least twice that found for the other varieties. The other varieties ranged close to 0·02 per cent. Pears were found to contain the least tannin of all the kinds of fruit analysed.

The average pectin content for the 19 samples of pears analysed was 0·59 per cent, ranging from a minimum of 0·28 to a maximum of 0·87 per cent. On the whole, the varieties, Bosc, Bartlett and Gorham were similar, yielding values close to that of the average for all varieties. The single lots of Flemish Beauty and Duchesse d'Angoulême analysed were low in pectin. As only single samples of Flemish Beauty, Duchesse d'Angoulême and Gorham varieties were analysed for pectin and only two lots of the Bosc variety, the results cannot be taken as being necessarily typical. Pears may be considered a fairly good source of pectin and compare favourably with apples. They are lower in this constituent than apricots, prunes or peaches, but markedly superior to cherries.

Discussion.—The average refuse figure was slightly greater than that reported by Chatfield and McLaughlin (45) and lower than that found by McCance and Widdowson (100). There are very wide variations in figures obtained for percentage skins and cores in pears.

Total solids tended to be generally lower than reported by United States investigators for the same varieties, notably Bosc, but similar to data reported by Gerhardt and Ezell in Washington State (70) for Anjou. The average also was the same as that reported for English pears (100). On the other hand the sugar content for Bartlett, Bosc and Anjou averaged the same or higher than that reported in the literature for these varieties (45, 70, 108). The minimum value for Bartlett pears was double that given by Chatfield and McLaughlin (45). The ratio of sucrose to reducing sugars was of the same general order as reported in the literature for ripened pears (2, 70, 108).

The average and range of total acid found, where comparable analyses were available for varieties, were in general agreement with published data from the United States (2, 45, 108). However, in the case of Flemish Beauty and Bosc the acid tended to be about double that found by Gerhardt and Ezell (70) for apparently comparable fruit. Few pH figures were observed in the literature for specific pear varieties but those of Moore (113) for Oregon, and Bridges and Mattice (36) were similar to those determined in this study for the same varieties. Townsend (158) indicated that pH values for California pears ranged somewhat higher at 4·3 to 4·7. Results of Gerhardt and Ezell in Washington (70) also indicated higher pH values (lower acidity). Because of the very low acidity, pears might be suggested as a desirable fruit for people who are afflicted with hyperacidity. On the other hand, low acid results in the possibility of greater difficulties in sterilization of the fruit in processing. From this latter

TABLE 6.—PROXIMATE COMPOSITION OF COMMERCIAL PEARS (SEASONS 1943–45 INCLUSIVE)

Variety[1]	Total refuse	Constituents as per cent by weight of fresh edible portion											
		Total solids	Soluble solids[2]	Water-insoluble solids	pH	Total acid[3]	Sugar as invert			Ash	Alkalinity of ash[4]	Tannin	Pectin as calcium pectate
							Total	Reducing	Sucrose				
	%	%	%	%		%	%	%	%	%		%	%
All varieties													
Average	21·5	16·08	13·6	2·08	3·77	0·32	9·53	7·89	1·84	0·28	41	0·025	0·59
Maximum	28·5	19·60	17·2	3·10	4·48	0·52	12·61	10·01	4·73	0·36	57	0·058	0·87
Minimum	18·3	12·36	11·1	1·29	3·24	0·13	7·87	6·27	1·03	0·19	26	0·015	0·28
Number of samples	36	45	24	26	42	42	46	25	25	26	25	7	19
COMMERCIAL VARIETIES													
Bartlett													
Average	21·3	15·56	13·2	2·36	3·73	0·38	9·27	8·00	1·49	0·28	41	0·019	0·60
Maximum	24·2	18·50	14·9	3·10	4·07	0·52	10·63	8·65	1·94	0·36	52	0·023	0·87
Minimum	19·4	13·53	11·9	1·86	3·50	0·25	8·25	6·84	1·03	0·21	34	0·015	0·43
Number of samples	18	26	13	13	22	22	26	10	10	11	11	3	8
Flemish Beauty													
Average	22·6	13·51	11·1	1·88	4·38	0·22	8·36	6·78	1·72	0·27	37	0·020	0·45
Maximum	28·5	15·12	11·1	2·31	4·48	0·28	9·09	7·04	2·00	0·34	44	—	—
Minimum	18·3	12·36	—	1·29	4·28	0·17	6·27	6·27	1·60	0·21	26	—	—
Number of samples	5	4	1	5	5	5	5	4	4	4	4	1	1
Bosc													
Average	21·9	16·43	14·1	1·77	3·70	0·21	11·09	7·71	3·39	0·26	38	—	0·59
Maximum	26·9	17·31	14·1	1·87	4·22	0·26	12·53	8·12	4·73	0·29	44	—	0·59
Minimum	19·5	15·43	14·0	1·67	3·24	0·16	10·11	7·45	2·64	0·19	39	—	0·58
Number of samples	14	4	2	2	4	4	4	4	4	4	4	—	2

Anjou													
Average	20·8	15·83	14·5	1·55	4·10	0·28	9·72	7·61	1·89	0·30	39	0·022	0·71
Maximum	24·2	16·08	15·0	1·69	4·20	0·33	12·53	8·15	2·09	0·33	43	0·026	0·74
Minimum	18·6	14·26	13·7	1·43	3·93	0·24	9·42	7·33	1·27	0·27	34	0·018	0·68
Number of samples	4	5	2	5	5	5	5	3	3	3	3	2	2
MISCELLANEOUS VARIETIES													
Duchesse d'Angoulême[5]	18·8	13·34	11·9	—	4·39	0·13	8·73	—	—	—	—	—	0·28
Gorham[6]	—	15·62	14·4	—	3·74	0·38	10·40	9·14	1·27	0·27	43	—	0·62

[1] Commercial varieties arranged in order of harvesting; Bartlett and Flemish Beauty are fall varieties, Anjou and Bosc are winter varieties.
[2] By refractometer at 20°C.
[3] Calculated as anhydrous citric acid.
[4] Millilitres of 0·1 Normal acid required to neutralize the ash from 100 grams of fresh material.
[5] Single sample.
[6] Average of two samples.

Fig. 6. A pressure tester is used to ensure that pears are picked at the proper stage of maturity to give maximum quality.

point of view, Bartlett is the easiest pear variety to sterilize in canning because it has the lower pH value and Flemish Beauty the most difficult as indicated by the higher pH values (lower acidity).

No significant difference was found in the ash and alkalinity values obtained for pears in this study from those reported in the literature (45, 81, 100, 113, 167).

With respect to tannin, what little published information is available was in agreement with the writers' findings that pears are very low in this constituent (70, 167).

Limited comparative data on soluble pectin in pears were found in the literature. The values for pectin obtained in this investigation for limited analyses of Anjou, Bosc and Flemish Beauty varieties tended to be slightly

but not necessarily significantly greater than those recorded by Gerhardt and Ezell (70) for these apparently optimum ripened Washington State varieties as determined by the Carré and Haynes calcium pectate method which is a similar procedure to that employed by the writers. Using the same method in studying pectin changes in Bartlett pears as affected by different storage conditions, Gerhardt and Ezell (69) and Smock and Allen (146) reported soluble-pectin contents in ripened fruit of 0·6 to 1·0 per cent as compared with the range found in this study of 0·43 to 0·87 for a greater number of samples. Several investigators have indicated the marked effect of degree of ripeness on the soluble-pectin content. Under-ripe and over-ripe fruit are reported to be lower in soluble pectins than optimum handled and ripened fruit.

Prunes (Italian)

Thirty samples of Italian prunes were analysed. The results for the seasons 1943-1945 are reported in Table 7.

The refuse content of prunes, which is made up almost entirely of pits, ranged from 3·6 to 7·9 per cent with an average value of 5·8 per cent. Prunes showed the smallest percentage waste of the various kinds of fruit tested.

For the 3-year period, the average sugar content of the fruit varied from a minimum of 7·39 to a maximum of 13·71 per cent with an average of 10·47 per cent. The 1944 average was about 1·4 per cent lower than that for the other 2 years. This condition may be attributed to variability in harvesting maturity more than to seasonal variation. A great deal of variation was noted in the quality and composition of the commercially packaged fruit. Good quality was found to be associated with higher sugar and decreased acid content. In the poorer quality lots the amount of acid as compared with sugar was relatively high.

About 56 per cent of the sugar found in prunes is sucrose. Samples of prunes having a sugar content of greater than 9 per cent and a sugar-acid ratio of 8:1 or greater were of fair to good quality. As total sugar comprises approximately 62 per cent of the soluble solids in Italian prunes as determined by the refractometer, the refractometer reading corresponding to 9 per cent actual sugar in the fruit would be 14·5 per cent. As with other stone fruits, the final quality of the fruit is determined by harvest time. Immature, red coloured prunes of low sugar and high acid content will never develop satisfactory quality. On holding, this immature fruit will improve somewhat in texture and colour but it will not improve to any significant extent in flavour and eating quality. Prunes with a refractometer reading of at least 15 per cent soluble solids are of fairly good colour, mildly sour but of fair flavour and will keep satisfactorily for a reasonable length of time. However, other studies at the Summerland Experimental Station have indicated that a minimum soluble-solids content by refractometer of 17 per cent would be preferable from a quality standpoint for both fresh market and cannery prunes.

In total acid the prunes ranged from a minimum of 0·98 per cent to a maximum of 1·64 per cent, averaging 1·24 per cent. The average obtained in 1944 was 0·12 per cent lower than that obtained in 1943. The acid range between samples was observed to be greater in 1943 than in 1944; but on the whole, differences were negligible in good samples of fully matured fruit.

There was little variation in the range of pH values found for the two seasons in which determinations were made. The average pH was 3·41 with minimum and maximum values of 3·26 and 3·61 respectively.

Insoluble solids averaged 1·15 per cent for two years. The average values for 1943 and 1945 were respectively 1·24 and 0·98 per cent. Minimum and maximum values recorded for both years were respectively 0·83 and 1·42 per cent.

TABLE 7.—PROXIMATE COMPOSITION OF COMMERCIAL ITALIAN PRUNES (SEASONS 1943–45 INCLUSIVE)

Year	Total refuse	Constituents as per cent by weight of fresh edible portion											
		Total solids	Soluble solids[1]	Water-insoluble solids	pH	Total acid[2]	Sugar as invert			Ash	Alkalinity of ash[3]	Tannin	Pectin as calcium pectate
							Total	Reducing	Sucrose				
	%	%	%	%		%	%	%	%	%		%	%
1943–45													
Average	5·8	17·68	15·9	1·15	3·41	1·24	10·47	4·65	5·39	0·45	61	0·122	0·93
Maximum	7·9	21·38	19·3	1·42	3·61	1·64	13·71	5·39	7·71	0·54	67	0·213	1·01
Minimum	3·6	12·79	11·3	0·83	3·26	0·98	7·39	3·59	3·59	0·33	53	0·072	0·81
Number of samples	30	23	14	14	17	17	23	7	7	9	8	6	14
1943													
Average	6·0	18·38	—	1·24	3·44	1·29	10·96	4·72	5·50	0·49	66	—	—
Maximum	7·9	21·38	—	1·42	3·61	1·64	13·71	5·36	7·71	0·54	67	—	—
Minimum	3·6	15·64	—	1·05	3·26	1·03	8·37	3·67	3·18	0·46	65	—	—
Number of samples	22	9	—	9	9	9	9	5	5	5	4	—	—
1944													
Average	5·4	16·70	15·5	—	3·37	1·17	9·56	4·49	5·13	0·41	57	—	0·92
Maximum	6·3	19·94	18·7	—	3·49	1·37	11·52	5·39	6·13	0·47	59	—	1·01
Minimum	3·9	12·80	11·7	—	3·26	0·98	7·39	3·59	4·13	0·33	53	—	0·81
Number of samples	8	8	8	—	8	8	8	2	2	4	4	—	8
1945													
Average	—	17·93	16·4	0·98	—	—	10·95	—	—	—	—	0·122	0·94
Maximum	—	20·38	19·3	1·09	—	—	13·07	—	—	—	—	0·213	1·00
Minimum	—	12·79	11·3	0·83	—	—	7·76	—	—	—	—	0·072	0·86
Number of samples	—	6	6	5	—	—	6	—	—	—	—	6	6

[1] By refractometer at 20°C.
[2] Calculated as malic acid.
[3] Millilitres of 0·1 Normal acid required to neutralize the ash from 100 grams of fresh material.

The ash content of prunes ranged from 0·33 to 0·54 with an average of 0·45 per cent for 9 samples analysed in 1943-1944. The average alkalinity of ash was 61 with a maximum of 67 and minimum of 53. It has been commonly believed that the apparently good potential alkalizing properties of prunes were misleading and that prunes were actually acidic in their ultimate effect. However, work by Mrak, Smith, Fessler, Lambert and Harper (117) indicates this view to be erroneous. These investigators, using human subjects, have shown that prunes fed even in large amounts have no significant effect on the alkaline reserve. In other words, prunes do not affect adversely the blood alkali reserve and hence do not produce "dietary acidosis".

The tannin content of Italian prunes was found to average 0·122 per cent with minimum and maximum values respectively of 0·072 and 0·213 per cent. Prunes were similar to cherries in that samples high in tannin and acid but low in sugar were of poor quality. Generally such fruit had been harvested at too immature a stage.

Italian prunes were found to be rich in pectin, containing about the same amount as apricots. They averaged 0·93 per cent pectin with a maximum of 1·01 and a minimum of 0·81 per cent. As indicated by the maximum and minimum values the variation in pectin content between samples and between seasons was small.

Limited analyses and observations of the early strains of Italian prunes, Greata and DeMaris, indicate that these strains are quite similar in composition, quality and other characteristics to standard Italian prunes when each fruit is harvested at corresponding maturities as determined by size, skin and flesh colour. Depending on the season, Greata and DeMaris are ready to harvest 2 to 3 weeks before Italian prunes.

Discussion.—Refuse values were similar to those given by Chatfield and McLaughlin (45) and Shaw (138). It is very difficult to compare the total solids, soluble solids, sugars and acid content of fresh prunes with analyses from other areas because of the great variability of these constituents with harvest maturity (12, 78, 161) and difficulty of determining whether the results reported were on fruit of comparable maturity when analysed. Furthermore, many of the data available on Italian prunes are related to the dried rather than the fresh product. As currently harvested in British Columbia for fresh fruit shipment, Italian prunes tend to be slightly lower in total solids, soluble solids and sugar, and markedly higher in acid than determinations reported for Oregon and Idaho (78, 87, 138, 161).

A better quality prune is attainable most seasons by leaving the fruit a few days longer on the tree to permit more sugar formation and reduction in acid content while at the same time retaining a desirable firmness. Quality also can be improved by grading for size which is related to chemical composition, especially sugar content, Atkinson and Strachan (13).

Present British Columbia recommendations are that prunes should have a minimum soluble-solids reading by refractometer of 17 per cent for fresh or canning purposes. Tucker and Verner (161) indicate that for harvesting Idaho Italian prunes a minimum soluble-solids content of 17 to 19 per cent is required to give fair flavoured prunes, while good to very good prunes have a soluble-solids content of 19 to 22 per cent with corresponding total acid contents ranging from about 1·0 to 0·6 per cent.

In some seasons, too great a proportion of the British Columbia prune crop may fall into the poor or cull grade. Before reaching a satisfactory sugar and acid content the fruit may become too soft to carry to market in good condition. It would appear advisable in areas subject to short seasons to plant early maturing strains of Italian prunes such as Greata and DeMaris which may be

harvested at least 2 weeks in advance of standard Italian prunes but have the required sugar content and other desirable characteristics of Italian prunes, Mann and Keane (103).

No comparable data were found in the literature on ash, insoluble solids, pectin or tannin content of fresh Italian prunes.

ASCORBIC ACID (VITAMIN C) CONTENT OF B.C. TREE FRUITS

Three hundred and seventy-five samples of fruit were analysed for ascorbic acid during the seasons 1944 to 1947. The results are summarized for each kind and variety of fruit in Tables 10, 14, 16, 18, 20 and 22. The probable mode for some of the fruits as indicated by the percentage of samples in ascorbic acid ranges of 3 milligrams (mg.) is presented in Tables 9, 15, 17, 19, and 21. Data are given in Table 11 showing the effect of cold storage on the ascorbic-acid content of apples and in Table 12 the effect of peeling on ascorbic-acid content of the fruit is shown.

In order to assist in evaluating the results, the number of samples analysed is given in each case. The results are based on 3 years' work with apples and cherries, and 2 years with each of the other fruits.

In evaluating the fruit as to its importance as a source of ascorbic acid, the values given in the Food and Drugs Act of Canada (122) were used as a basis. According to the regulations under this Act a food may be described as an "excellent" or "good" dietary source of vitamin C (ascorbic acid) provided the food contributes not less than 15 mg. or 7·5 mg. respectively of vitamin in a reasonable daily intake of the food as ordinarily consumed. This definition was employed to classify a fruit as an "excellent" or "good" source of ascorbic acid. The term "fair" was arbitrarily chosen to describe a fruit contributing between 7·5 and 4 mg., and the word "poor" to describe fruit contributing less than 4 milligrams. In this report, for convenience and practicability, 100 grams ($3\frac{1}{2}$ ounces) of edible fruit was taken as the basis for a "reasonable daily intake". It is recognized, of course, that in many instances much greater portions of fruit might be consumed.

The new dietary standard for Canada approved by the Canadian Council on Nutrition, December 7, 1948 (153) tentatively sets the standard maintenance allowance for vitamin C (ascorbic acid) at 30 mg. daily irrespective of age, weight, or degree of activity. Thus, a single $3\frac{1}{2}$-ounce serving of fruit classified in this report as an "excellent" source of ascorbic acid would supply more than 50 per cent of the daily requirement of ascorbic acid while a fruit classified as a "good" dietary source would supply 25 to 50 per cent.

Apples

One hundred and seventy-eight samples of 38 varieties of apples were analysed during the three seasons 1944 to 1946. The results are reported in Tables 8 to 12 inclusive. These analyses include a number of new varieties developed at the Experimental Station, Summerland.

The data presented in Table 8 show the wide range possible in ascorbic-acid content of the commercial varieties of apples currently produced and marketed. The ascorbic-acid content of all varieties of apples is seen to range in the 3-year period from 1·2 to 20·9 mg. with an average value of 7·8 mg., and the more economically important principal varieties varied from a minimum of 1·2 mg. to a maximum of 17·1 mg. with an average figure of 6·9. Table 9 indicates good agreement between the average and mode as calculated on 100 or more samples. Thirty-one per cent of the principal varieties were found to be in the modal class of 6 to 8·9 mg. of ascorbic acid with 74 per cent having values of 3 to 11·9 mg. Many apples thus are a fair to good source of vitamin C.

Fig. 7. The Jubilee apple, originated by the Summerland Experimental Station, contains more ascorbic acid (vitamin C) than most of the main commercial varieties.

It will be noted from Tables 8 and 9 that there were marked varietal differences with respect to ascorbic-acid content. Of the main commercial varieties, Golden Delicious, Jubilee, Newtown, Rome Beauty and Winesap averaged close to 10 mg. of ascorbic acid with over 80 per cent of the fruit containing more than 6 mg. of ascorbic acid. Two of the miscellaneous varieties, Wagener and Northern Spy were outstanding with average ascorbic-acid values of 18·6 and 16·4 mg. respectively. On the other hand, it is unfortunate that several of the higher quality dessert apples, Delicious, Jonathan and especially McIntosh and Spartan were low in vitamin C. Ninety per cent of the McIntosh and 70 per cent of Spartan apples contained less than 3 mg. of ascorbic-acid per 100 grams ($3\frac{1}{2}$ ounces).

Some varieties of apples, for instance, Golden Delicious, Jubilee and Rome Beauty, showed a wide distribution of ascorbic acid while others, for example, red strains of Delicious, Jonathan, McIntosh, Newtown, Spartan and Stayman showed a relatively narrow range. Of the new introductions, Jubilee was found to be a good source of ascorbic acid with 62 per cent of the samples containing more than 9 mg. Minimum and maximum values for this variety were 7·9 and 15·0 mg. respectively.

While varietal differences were dominant, there appeared to be some seasonal variations. However, the seasonal data were insufficient to be conclusive.

The apple varieties studied in this investigation may be grouped according to their average ascorbic acid content as follows: excellent—Wagener and Northern Spy with 15 or more mg. per 100 grams; good—Rome Beauty, Jubilee, Newtown, Golden Delicious, Spitzenberg, Winesap, Winter Banana, 7·5 to 15 mg.; fair—Jonathan, Delicious (red strains), Delicious, Stayman, Stirling, 4 to 7·5 mg.; and poor—Wealthy, Spartan and McIntosh with 0 to 4 mg.

A limited number of analyses were made on samples of new varieties under test at the Experimental Station, Summerland, results being presented in Table 10. The highest value obtained was 12·3 mg. with the numbered variety, S1-6(C). Eleven other varieties ranged from 2·3 to 8·5 mg. Most of these new varieties are crosses in which McIntosh is one of the parents. Unfortunately, low ascorbic acid content characteristic of this variety usually appears to be dominant in the cross and consequently the new varieties also tend to be low in ascorbic acid.

TABLE 8.—ASCORBIC ACID CONTENT OF COMMERCIAL APPLES (SEASONS 1944-46 INCLUSIVE)

Variety[1]	Ascorbic acid content in milligrams per 100 grams of fresh edible portion								
	1944		1945		1946		Summary 1944–1946		
	Number of samples	Average	Number of samples	Average	Number of samples	Average	Number of samples	Average	Range
		mg.		mg.		mg.		mg.	mg.
All varieties	46	8·9	46	6·9	53	7·7	145	7·8	1·2—20·9
Principal commercial varieties	44	8·0	23	6·2	33	6·0	100	6·9	1·2—17·1
Delicious	6	5·7	3	4·7	—	—	9	5·4	2·4— 7·5
Delicious-Red Strains[2]	4	6·6	2	6·1	3	5·6	9	6·3	5·1— 7·2
Golden Delicious	8	10·7	2	7·9	1	6·6	11	9·8	5·5—15·6
Jonathan	2	6·2	1	8·0	5	6·1	8	6·6	5·6— 8·0
Jubilee	2	10·6	1	15·0	5	9·5	8	10·4	7·9—15·0
McIntosh	4	2·1	3	2·4	3	2·3	10	2·2	1·2— 3·0
Newtown	4	11·0	2	7·4	4	9·8	10	9·8	6·8—11·3
Rome Beauty	2	13·2	2	11·9	2	8·0	6	11·0	5·1—17·1
Spartan	2	3·3	2	3·6	6	2·1	10	2·7	1·5— 4·3
Stayman	4	6·6	2	5·2	2	5·3	8	5·9	4·3— 6·8
Wealthy	—	—	1	3·6	1	3·6	2	3·6	—
Winesap	6	10·1	2	5·4	1	6·4	9	9·3	4·5—10·5
Miscellaneous varieties									
Grimes Golden	—	—	—	—	1	7·7	1	7·7	—
Northern Spy	—	—	1	14·8	3	17·0	4	16·4	13·3—19·2
Spitzenberg	—	—	1	10·2	2	9·8	3	10·0	9·7—10·2
Stirling	2	6·1	1	4·3	4	2·9	7	4·7	2·8— 6·2
Wagener	2	20·9	2	15·0	4	19·0	8	18·6	14·7—20·9
Winter Banana	—	—	2	8·8	1	10·5	3	9·4	8·7—10·5

[1] Varieties arranged alphabetically in each group.
[2] Mostly Turner and Richared.

TABLE 9.—DISTRIBUTION OF ASCORBIC ACID VALUES OF COMMERCIAL APPLES (SEASONS 1944–46 INCLUSIVE)

Variety[1]	Number of samples	Percentage of samples in 3 milligram ascorbic acid classes							Mode[2]	Average[2]
		0-2·9	3·0-5·9	6·0-8·9	9·0-11·9	12·0-14·9	15·0-17·9	18·0-20·9		
		%	%	%	%	%	%	%	mg.	mg.
All varieties	128	15·6	22·7	27·3	18·0	6·2	4·7	5·5	7·3	7·8
Principal commercial varieties	100	17·0	25·0	31·0	18·0	5·0	4·0	—	7·3	6·9
Delicious	9	11·1	56·6	33·3	—	—	—	—	5·3	5·4
Delicious–Red Strains[3]	9	—	33·3	66·7	—	—	—	—	6·0	6·3
Golden Delicious	11	—	18·2	36·3	9·1	18·2	18·2	—	7·0	9·8
Jonathan	8	—	50·0	50·0	—	—	—	—	6·0	6·6
Jubilee	8	—	—	37·5	37·5	12·5	12·5	—	10·0	10·4
McIntosh	10	90·0	10·0	—	—	—	—	—	3·0	2·2
Newtown	10	—	—	30·0	70·0	—	—	—	9·0	9·8
Rome Beauty	6	—	16·6	16·7	16·7	33·3	16·7	—	13·5	11·0
Spartan	10	70·0	30·0	—	—	—	—	—	3·0	2·7
Stayman	8	—	37·5	62·5	—	—	—	—	6·0	5·9
Wealthy	2	—	100·0	—	—	—	—	—	3·6	3·6
Winesap	9	—	11·1	22·2	66·7	—	—	—	9·0	9·3
Miscellaneous varieties										
Northern Spy	4	—	—	—	—	50·0	—	50·0	—	16·4
Spitzenberg	3	—	—	—	100·0	—	—	—	10·0	10·0
Stirling	7	28·6	57·1	14·3	—	—	—	—	4·0	4·7
Wagener	8	—	—	—	—	12·5	25·0	62·5	18·0	18·6
Winter Banana	3	—	—	66·7	33·3	—	—	—	9·0	9·4

[1] Varieties arranged alphabetically in each group.
[2] Ascorbic acid in milligrams per 100 grams of fresh edible portion.
[3] Mostly Turner and Richared.

The effect of extended cold storage on the ascorbic-acid content of a number of commercial varieties of apples was determined. Boxes of apples were taken at the time of packing following harvesting. A portion of each box was ripened and analysed when the apples were in prime eating condition. The remaining portions were stored immediately at 32° F. (0°C.). After 5 months, samples were removed from storage and analysed as before. The results are tabulated in Table 11. In most instances, ascorbic acid loss during storage was insignificant, being less than 1 mg. Golden Delicious, Newtown and one lot of Wagener showed ascorbic acid increases on whole fruit of 0·7 mg. for Golden Delicious, 0·8 and 2·6 mg. for two samples of Newtown and 0·4 mg. for Wagener. However, another sample of Wagener showed a loss of 0·2 mg. Analyses of the peeled and cored fruit gave data essentially similar to that obtained on unpeeled, cored fruit. The small differences found between the original analyses and those of the stored fruit were even less for the peeled and cored apples. From these results, it appears that apples harvested at optimum maturity and in good condition undergo little or no loss in ascorbic-acid content during 5 months' storage at 32° F.

Results from the analyses of 17 varieties indicate that 20 to 61 per cent of the ascorbic-acid value of an apple is contained in the skin or peel (Table 12). The average value for all varieties was 36 per cent. The ratio of the ascorbic acid in peel to that in the pulp was calculated. These ratios varied, as indicated in Table 12, from 3·1 for Northern Spy to 11·2 for McIntosh with an average ratio for all varieties of 5·4.

Discussion.—A review of the literature showed that the ascorbic-acid content of apples grown in British Columbia is at least as high as that of corresponding varieties grown in other areas, and in several instances appears to be slightly superior. Published data on vitamin C content of apples under varying conditions are relatively voluminous. The ascorbic-acid range found for all varieties analysed in this study was similar to the range of 0·1 to 20 mg. reported by Fixsen and Roscoe (66) in their literature survey previous to 1940.

Some minimum and maximum values per 100 grams reported by other investigators since 1940 are: Wolf (169) for 109 varieties of German apples, 2·3 to 30·9 mg. (unpeeled); Keisser and Pollard (92) for 17 varieties of English

TABLE 10.—ASCORBIC-ACID CONTENT OF SOME NEW APPLE VARIETIES UNDER TEST DURING 1944-46 AT THE EXPERIMENTAL STATION, SUMMERLAND

Variety	Number of samples	Average ascorbic acid content[1] in milligrams per 100 grams
		mg.
S3-1[2]	3	5·0
S3-11	1	5·4
S4-8	1	2·3
S4-14	1	5·5
S5-4[2]	4	2·3
S5-6	1	8·5
S5-13	1	6·3
S1-6(C)	1	12·3
S2-10(C)	1	5·9
S3-8(C)	1	6·4
S4-5(C)	1	4·6
S5-13(C)	1	3·6
Cox Orange on Rootstock IX	1	9·9
Linda	2	8·5
Secor	2	9·2
Sharon	1	4·5

[1] Determined on cored but unpeeled fruit.
[2] Values recorded for S3-1 and S5-4 each represent average of two seasons' results.

TABLE 11.—ASCORBIC-ACID CONTENT OF APPLES AS AFFECTED BY FIVE MONTHS' STORAGE AT 31-32°F. (0°C.)

Variety[1]	Ascorbic acid content in milligrams per 100 grams			
	Whole fruit (cored)		Peeled and cored fruit	
	Original	After 5 months at 32°F.	Original	After 5 months at 32°F.
	mg.	mg.	mg.	mg.
Golden Delicious	6·6	7·3	4·1	4·9
Newtown	6·8	7·6	—	—
Newtown	7·9	10·5	5·7	6·5
Northern Spy	14·8	13·9	11·6	10·9
Rome Beauty	6·7	6·1	3·4	3·3
Spitzenberg	10·2	9·7	8·3	8·0
Stayman	4·8	3·3	2·9	2·5
Wagener	14·7	15·1	12·7	14·4
Wagener	16·3	16·1	11·8	12·5
Winesap	6·3	5·7	3·8	3·5

[1] Varieties arranged alphabetically.

TABLE 12.—ASCORBIC-ACID CONTENT OF APPLES AS AFFECTED BY PEELING

Variety[1]	Ascorbic acid content in milligrams per 100 grams			Percent ascorbic acid lost on peeling	Ratio of ascorbic acid in peel to flesh
	Whole fruit (cored)	Peeled and cored fruit	Peel only		
	mg.	mg.	mg.	%	
Delicious–Red Strains	7·2	4·9	23·2	32	4·7[2]
Golden Delicious	6·6	3·6	20·1	45	5·6
Grimes Golden	7·7	5·4	21·9	30	4·1
Jonathan	6·4	3·8	18·6	40	4·9
Jubilee	8·2	5·1	27·7	38	5·4
McIntosh	2·6	1·0	11·2	61	11·2
Newtown	11·3	7·2	44·1	36	6·1
Northern Spy	13·3	10·7	33·3	20	3·1
Rome Beauty	11·0	6·9	36·5	37	5·3
Spartan	2·0	1·5	5·1	25	3·4
Spitzenberg	10·2	7·7	26·3	25	3·4
Stayman	6·4	3·8	22·6	40	6·0
Stirling	2·8	1·8	8·8	36	4·9
Wagener	18·9	12·8	50·4	32	3·9
Wealthy	3·6	1·8	14·6	50	8·1
Winesap	6·4	4·1	28·1	36	6·9
Winter Banana	10·5	6·9	32·8	34	4·8
Average				36	5·4
Range				20–61	3·1–11·2

[1] Varieties arranged alphabetically.
[2] Ratio 4·7:1.

apples, 6·9 to 22·5 mg.; Esselen *et al.* (59) for 69 varieties of apples grown in Massachusetts, 0·7 to 11·6 mg.; Griffee (73) for 75 varieties of Maine-grown apples, 2·0 to 27·5 mg.; Eheart (58) for 22 varieties of Virginia-grown apples reported minimum-maximum values of 0·9 to 10·5 mg. (unpeeled); Howe and Robinson (85) for a large number of apple varieties and seedlings in New York State, 2 to 37 mg. (unpeeled); Davis (55), MacArthur and Johnston (99), and Grant (72) for over 600 apple varieties and crosses grown at the Central Experimental Farm, Ottawa, Ontario, 0·4 to 36·2 mg. including both peeled and unpeeled fruit; Branion *et al.* (35) for 58 assays of raw apples used in Canada, an average value of 5·3 mg. As shown later, analyses of unpeeled fruit usually yielded significantly greater ascorbic-acid values than those obtained on corresponding peeled apples.

High ascorbic-acid values exceeding 20 mg. almost without exception were for varieties or seedlings of very inferior quality or other faults from a commercial growing and marketing viewpoint. Generally these varieties with high ascorbic-acid content were of a local nature and produced in limited quantities. Both Sturmer and Calville Blanc varieties, reported to contain in the unpeeled fruit close to 30 and 40 mg. per 100 grams respectively, are not satisfactory dessert apples from an appearance or eating quality standpoint. These varieties once were grown at the Experimental Station, Summerland, and the Central Experimental Farm, Ottawa, but were discarded long ago as being definitely unsuitable.

All data point to the fact that the most important single factor affecting ascorbic-acid content of apples is a genetic one of varieties. Howe and Robinson (85) and others have indicated that high vitamin C content in apples can be transmitted from parent to offspring. Thus these high ascorbic-acid content varieties do offer possibilities of breeding varieties of dessert apples of high vitamin C value combined with good market qualities. This is a very slow task but a start has been made by some investigators and many are now aware that the breeding of high vitamin C content apples might well be considered.

When the ascorbic-acid content of the principal commercial varieties of apples grown in British Columbia is compared with reported values for the same varieties grown elsewhere (Table 13), analysed so far as could be determined under relatively comparable conditions, it is seen that the British Columbia fruit is at least equal and frequently superior in vitamin C value. In a number of instances the differences are insignificant as slight variations in conditions of storage, ripeness or season could more than account for them. Unfortunately the published data available for this comparison are limited and much of that reported for Washington was obtained prior to 1940.

The ascorbic-acid content of cold stored apples appears to depend primarily on storage temperature, length of storage and to some degree on variety. Batchelder (18), Batchelder and Overholser (19), Grant (72), Keys (90) and Todhunter (156) found little or no loss in ascorbic-acid content of apples stored at 32° F. (0°C.) for periods up to 6 to 9 months, which is in agreement with the results of this investigation. However, some workers have reported significant losses in ascorbic acid at this temperature, the degree of loss apparently being correlated with variety (7, 64). There is general agreement in the literature that storage of apples at temperatures exceeding 32° F. and especially above 40° F. results in greatly reduced ascorbic-acid content. The percentage loss increases with temperature rise and time (58, 156).

Eheart (58) and Murneek and Wittwer (118) discuss some of the many factors affecting ascorbic-acid content of apples and probably other fruits. Delayed storage for even a few days at 70 to 80° F. was shown to result in a markedly decreased vitamin C content, being sometimes as much as 30 per cent of the original value in 6 days (118).

TABLE 13.—A COMPARISON OF THE ASCORBIC-ACID CONTENT OF PRINCIPAL COMMERCIAL VARIETIES OF APPLES GROWN IN BRITISH COLUMBIA AND THE SAME VARIETIES GROWN ELSEWHERE[1]

Variety	Ascorbic-acid content in milligrams per 100 grams of fresh edible portion									
	British Columbia		Ontario (Ottawa)[2]		Washington[3]		Virginia[4]		Massachusetts[5]	New Zealand[6]
	Range	Average	Range	Average	Range	Average	Range	Average	Average	Average
	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Delicious	2·4— 7·5	5·4	—	—	1·7—3·0	2·5	1·8—4·4	2·5	4·9	5·3
Delicious–Red Strains	5·1— 7·2	6·3	—	—	—	2·5	—	—	—	—
Golden Delicious	5·5—15·6	9·8	—	—	3·5—7·0	5·0	2·8—4·6	3·9	1·7	—
Jonathan	5·6— 8·0	6·6	—	—	—	2·5	1·4—3·7	2·7	3·3	6·4
Jubilee	7·9—15·0	10·4	7·2—9·3	8·1	—	—	—	—	—	—
McIntosh	1·2— 3·0	2·2	1·6—2·4	2·0	—	—	—	—	3·1	—
Newtown	6·8—11·3	9·8	—	—	—	5·0	—	—	—	—
Rome Beauty	5·1—17·1	11·0	—	9·4	1·8—7·2	5·0	2·7—5·1	3·5	6·6	2·7—6·2
Spartan	1·5— 4·3	2·7	1·8—2·6	2·2	—	—	—	—	—	—
Stayman	4·3— 6·8	5·9	—	—	—	4·5	1·8—4·9	3·3	5·8	—
Wealthy	—	3·6	2·2—4·1	3·4	—	—	—	—	3·2	—
Winesap	4·5—10·5	9·3	—	—	3·0—6·8	5·0	2·6—4·7	3·5	6·6	—

[1] Analysed so far as could be determined under relatively comparable conditions.
[2] References 55, 72, 99.
[3] References Todhunter (155, 156, 157).
[4] References, Eheart (58).
[5] References, Esselen *et al* (59).
[6] References, Askew and Kidson (7) and Kidson (91).

A few investigators have reported increased ascorbic-acid values during storage at 32°F. (139, 141). The work in England of West and Zilva (165) with Bramley's Seedling variety showed that synthesis of vitamin C and transformation of dehydroascorbic acid to ascorbic acid took place during cold storage (3°C.).

The skin of the apple was found by the writers to be much richer in ascorbic acid than the cortex and there was considerable variation between varieties in ratio of ascorbic acid in the peel to that in the flesh. These results are in agreement with the findings of other investigators, although in some cases there was slight variation in the ratios reported for specific varieties (58, 72, 74, 156).

Apricots

The fruits of 62 samples of apricots were analysed during the 1945-46 seasons. The major portion of samples were of the following principal commercial varieties; Wenatchee Moorpark, Blenheim (Royal), Tilton and Kaleden. Other varieties assayed to a very limited extent, including several new ones under test at the Experimental Station, Summerland, were Perfection, Ryland, Leslie, Rose, 27-3 and 27-5. Table 14 shows the average ascorbic-acid content found for the various varieties as well as the minimum and maximum values. In Table 15 is given the percentage of samples of the main commercial varieties occurring in frequency ranges of 3 mg. of ascorbic acid.

No outstanding ascorbic-acid values were obtained with apricots. The mean value for all varieties analysed was 8·8 mg. and ranged from 2·8 to 14·6 mg. The ascorbic-acid content of varieties studied for 2 years was from 0·8 to 2·7 mg. greater in 1946 than in 1945 indicating seasonal variation. There also appeared to be varietal differences. Each year, Blenheim averaged 1·7 to 2·5 mg. above the all-variety average. As shown in Table 15, all samples of Blenheim exceeded 6 mg. with 82 per cent having values of 9 to

TABLE 14.—ASCORBIC-ACID CONTENT OF COMMERCIAL APRICOTS (SEASONS 1945-46 INCLUSIVE)

Variety	Ascorbic-acid content in milligrams per 100 grams of fresh edible portion						
	1945		1946		Summary 1945–1946		
	Number of samples	Average	Number of samples	Average	Number of samples	Average	Range
		mg.		mg.		mg.	mg.
All varieties	22	8·0	40	9·3	62	8·8	2·8—14·6
Blenheim (Royal)	6	9·7	5	11·8	11	10·7	8·0—14·6
Kaleden	—	—	5	9·8	—	—	8·4—11·7[1]
Leslie	—	—	1	8·0	—	—	—
Perfection	—	—	2	10·3	—	—	—
Rose	—	—	2	8·3	—	—	—
Ryland	—	—	1	5·9	—	—	—
Tilton	4	5·8	6	8·5	10	7·4	2·8—10·0
Wenatchee Moorpark	12	8·0	16	8·8	28	8·5	5·3—12·4
No. 27–3	—	—	1	8·9	—	—	—
No. 27–5	—	—	1	10·2	—	—	—

[1] Figures for 1946 only.

TABLE 15.—DISTRIBUTION OF ASCORBIC-ACID VALUES OF COMMERCIAL APRICOTS (SEASONS 1945–46 INCLUSIVE)

Variety	Number of samples	Percentage of samples in 3 milligram ascorbic-acid classes					Mode[1]	Average[1]
		0–2·9	3·0–5·9	6·0–8·9	9·0–11·9	12·0–14·9		
		%	%	%	%	%	mg.	mg.
All varieties	62	1·6	6·5	48·4	37·0	6·5	8·6	8·8
Blenheim (Royal)	11	—	—	18·2	54·5	27·3	10·8	10·7
Kaleden	5	—	—	40·0	60·0	—	9·0	9·8
Tilton	10	10·0	—	80·0	10·0	—	7·5	7·4
Wenatchee Moorpark	28	10·7	—	50·0	35·7	3·6	8·3	8·5

[1] Ascorbic acid in milligrams per 100 grams of fresh edible portion.

14·9 mg. of ascorbic acid and 54 per cent being in the modal class, 9 to 11·9 mg. On the other hand, 10 to 11 per cent of the Wenatchee Moorpark and Tilton contained less than 6 mg. of ascorbic acid with 50 and 80 per cent respectively in the modal class 6·0 to 8·9 mg. The average values and calculated modes for the different varieties of apricots practically coincided in each case. In general, maturity at harvest within the range at which apricots are being picked commercially did not appear to significantly affect the ultimate ascorbic-acid content of the ripened fruit. According to the method of classification employed in this report, apricots may be considered a fair to good source of ascorbic acid.

Discussion.—In a survey of world literature, Fixsen and Roscoe (66) reported apricots to range from 0·8 to 16·0 mg. Lamb, Pressley and Zuch (94) in the course of a study on the retention of nutrients during commercial canning at factories in California and the Pacific Northwest area of the United States, found raw apricots to range from 8·2 to 12·6 mg. with an average value of 10·2 mg. Hill (82) studying the ascorbic-acid content of some Western Australian fruits, reported apricots to average 6·0 mg. and Diemair, Timmling and Fox (57) in Germany reported apricots to contain 1·8 mg. Truscott *et al.* (160) in 1942 analysed immediately following harvest, a few samples of Moorpark and Tilton apricots which had been grown at the Ontario Horticultural Experiment Station at Vineland. He found these varieties to contain about 12 and 20 mg. respectively. The value of 20 mg. for Tilton apricot is particularly high.

The ascorbic-acid content of apricots as determined in the present investigation proved to be very similar to that reported in the literature survey by Fixsen and Roscoe (66) of Great Britain and by the United States investigators Lamb, Pressley and Zuch (94). The average for varieties was slightly higher than that obtained for Western Australian apricots (82) and four to five times as high as recorded German figures. Where varieties could be compared the agreement with the results of other workers was good except for the value for Tilton given by Truscott (160). The conditions for the latter's analyses were optimum and hardly comparable with those existing in this investigation which simulated marketed fruit received by the consumer.

Cherries

Seventy-five samples of sweet cherries from various sections of the commercial fruit producing area were analysed for ascorbic acid. Bing and Lambert, the two chief commercial varieties for fresh fruit shipment in British Columbia comprised 75 per cent of the samples. Other varieties analysed were: Royal

Ann, Van, Victor, Deacon and Sparkle. Table 16 presents the yearly average ascorbic-acid content of cherries according to variety together with the extreme range for the three-year period. Table 17 shows the percentage of samples of each variety in ascorbic-acid ranges of 3 milligrams and also the mode and average.

Sweet cherries, other than the Bing variety, were found to be a fair to good source of ascorbic acid. The average for all varieties over the 3-year period was 9·4 mg. with minimum and maximum values of 1·1 and 24·8 mg. respectively. The Bing variety was consistently low, averaging only 4·6 mg. with 72 per cent (Table 17) of the samples containing less than 6 mg. and 38 per cent less than 3 mg., and only 27 per cent had values ranging from 6 to 11·9 mg. Lambert, on the other hand, was found to be a good to excellent source of ascorbic acid with a 3-year mean of 11·8 mg., with 93 per cent (Table 17) of the samples exceeding 6 mg. and 46 per cent containing 12 to 24·8 mg. While considerable variation existed within varieties from year to year, the results indicate that varietal difference exerted a greater influence on ascorbic-acid content of this fruit than any other factor.

On the limited number of samples analysed, Royal Ann cherries appeared to have an ascorbic-acid content quite similar to Lambert. Samples were mainly from the Experimental Station orchards hence do not truly reflect all the conditions encountered commercially with regard to location, harvesting and packing. Van, a promising new variety in the Experimental Station orchard, had a good to excellent ascorbic-acid content. The mean value for this variety was 14·6 mg. with minimum and maximum figures respectively of 9·9 and 17·3 mg. These values for Van are only indicative until the variety is more extensively grown.

The average ascorbic-acid value for all varieties was 1·8 mg. greater than the mode. In the Bing variety the figure for the mode was found to be in good agreement with the average. The mode for Lambert was calculated to be 8·1 mg. or 3·7 mg. less than the average value for this variety. The higher average

Fig. 8. The Van cherry, originated by the Summerland Experimental Station, combines high nutritive value with good cultural and marketing characteristics.

figure is due to the extreme values in ascorbic-acid content occurring in the different lots of Lambert. It is considered that the average in this case more truly represents the ascorbic-acid content of this variety as purchased, especially when at least 64 per cent of the Lambert packages contained 9 mg. or more of ascorbic acid. The samples of Royal Ann and Van are not sufficiently representative to indicate a true average or mode for these varieties under all conditions. Royal Ann cherries grown in British Columbia are allocated almost entirely to processing. Only single or duplicate lots of Victor, Deacon and Sparkle were tested, all originating in the Experimental Station orchard, so values at best are only indicative.

TABLE 16.—ASCORBIC-ACID CONTENT OF COMMERCIAL CHERRIES (SEASONS 1945–47 INCLUSIVE)

Variety	Ascorbic-acid content in milligrams per 100 grams of fresh edible portion								
	1945		1946		1947		Summary 1945–1947		
	Number of samples	Average	Number of samples	Average	Number of samples	Average	Number of samples	Average	Range
		mg.		mg.		mg.		mg.	mg.
All varieties....	13	8·3	49	7·6	13	14·6	75	9·4	1·1—24·8
Bing.....	5	3·8	20	3·8	4	9·3	29	4·6	1·1—11·6
Deacon.....	1	8·0	1	9·0	—	—	2	8·5	—
Lambert.....	2	16·3	23	10·1	3	21·4	28	11·8	3·7—24·8
Royal Ann.....	2	9·0	1	14·0	4	15·9	7	13·7	8·7—18·2
Sparkle.....	—	—	2	11·5	—	—	—	—	—
Van.....	1	14·0	1	9·9	2	17·2	4	14·6	9·9—17·3
Victor.....	—	—	1	11·5	—	—	—	—	—

Within the commercial cherry-growing area of the Okanagan Valley of British Columbia, the area or location did not appear to affect the ascorbic acid values in any consistent manner. Data presented in Table 16 suggest that there may be significant seasonal variation, 1947 being a season favourable to high ascorbic-acid values and 1946 to low values. The information obtained in this study failed to explain such extreme values as 3·7 and 24·8 mg. secured on Lambert, low and high values, being found in samples of satisfactory condition and quality. The more mature cherries tended to be slightly higher in ascorbic-acid content than less mature cherries. Thus in limited tests, cherries of Bing, Lambert and Royal Ann varieties, having soluble-solids contents of 19 to 22 per cent, contained 2 to 4 mg. more of ascorbic acid than comparable samples having soluble-solids contents of 14 to 17 per cent.

Discussion.—A review of the literature revealed relatively few published analyses on the ascorbic-acid content of sweet cherries. Fixsen and Roscoe (66) in their survey of world literature up to 1940 indicated cherries to range in value from 3·1 to 17·0 mg. More recently European investigators have reported figures as follows: Schatzlein and Fox-Timmling (137), 2·6 to 7·0; Olejnicek and Hanzelka (123), 0·8 to 3·2. According to an anonymous report (5) from Buenos Aires, Argentine cherries averaged 10·6 mg. of ascorbic-acid. Sherman (143) gave the average range for cherries as 8 to 10 mg. but did not indicate whether this included sour cherries. In Canada, Branion *et al.* (35) reported Canadian cherries to average 10·5 mg. and Truscott *et al.* (160) found the Bing variety in a small sampling to contain 7·0 mg.

TABLE 17.—DISTRIBUTION OF ASCORBIC-ACID VALUES OF COMMERCIAL CHERRIES (SEASONS 1945-47 INCLUSIVE)

Variety	Number of samples	Percentage of samples in 3 milligram ascorbic acid classes									Mode[1]	Average[1]
		0–2·9	3·0–5·9	6·0–8·9	9·0–11·9	12·0–14·9	15·0–17·9	18·0–20·9	21·0–23·9	24·0–26·0		
		%	%	%	%	%	%	%	%	%	mg.	mg.
All varieties	75	14·7	16·0	22·7	18·7	13·3	9·3	4·0	—	1·3	7·6	9·4
Bing	29	37·9	34·5	20·7	6·9	—	—	—	—	—	4·1	4·6
Lambert	28	—	7·4	28·5	17·6	25·0	10·5	7·4	—	3·6	8·1	11·8
Royal Ann	7	—	—	14·3	14·3	28·6	28·5	14·3	—	—	14·0	13·7
Van	4	—	—	—	25·0	25·0	50·0	—	—	—	15·0	14·6

[1] Ascorbic acid in milligrams per 100 grams of fresh edible portion.

In comparing the results of this investigation with those previously reported, it may be seen that at the time of consumption, cherries produced in British Columbia are at least as high and in many cases superior in vitamin C content to those from other areas. Lambert, Royal Ann and the new variety, Van, were found to have very good ascorbic-acid content with averages above those previously reported for cherries. They also showed a high percentage of extreme values exceeding those given in the literature.

Peaches

Thirty-three lots of the following commercial varieties of peaches were analysed: Elberta, Fisher, J. H. Hale, Rochester, Valiant, Vedette, Veteran and a new early variety, Spotlight, recently developed at the Experimental Station, Summerland. For each variety the average ascorbic-acid content found during 1945-46 seasons is presented in Table 18. The distribution of ascorbic-acid values of the varieties is given in Table 19.

Peaches showed a mean ascorbic-acid content of 6·6 mg. and ranged from a minimum of 2·2 mg. to a maximum of 11·0 mg. The number of samples of each variety was not so great as desired, particularly for Rochester and Elberta varieties. On the basis of the results obtained in the current study there did not appear to be any marked seasonal or varietal differences. The seasons were relatively normal. Sixty-one per cent of the samples analysed contained between 6 and 8·9 mg. The mode and average for all varieties and for each variety gave almost identical values. Peaches may be classified as only a fair source of ascorbic acid.

Discussion.—There is considerable information available on the ascorbic-acid content of peaches from various parts of the world, particularly the United States. Peaches have been reported to contain usually from 1 to 12 mg. (47, 57, 66, 67, 93, 127, 129, 137, 140, 143, 152, 160). Many of the above investigators indicated the average values to be 2 to 6 mg. One or two reports have shown that some peaches might have relatively high values. Hill (82) found Elberta peaches in Western Australia to contain 17 mg. of ascorbic acid.

TABLE 18.—ASCORBIC-ACID CONTENT OF COMMERCIAL PEACHES
(SEASONS 1945-46 INCLUSIVE)

Variety	Ascorbic-acid content in milligrams per 100 grams of fresh edible portion						
	1945		1946		Summary 1945–1946		
	Number of samples	Average	Number of samples	Average	Number of samples	Average	Range
		mg.		mg.		mg.	mg.
All varieties	28	6·4	5	7·9	33	6·6	2·2—11·0
Elberta	2	6·1	—	—	—	—	—
Fisher	1	6·3	1	6·5	2	6·4	—
J. H. Hale	6	5·8	—	—	—	—	3·1— 8·6[1]
Rochester	2	9·7	1	9·1	3	9·5	8·4—11·4
Spotlight	—	—	1	7·1	—	—	—
Valiant	5	6·6	1	10·2	6	7·2	4·7—10·2
Vedette	7	7·2	—	—	—	—	6·6— 7·8[1]
Veteran	5	4·8	1	6·4	6	5·1	2·2— 7·8

[1] Figures for 1945 only.

TABLE 19.—DISTRIBUTION OF ASCORBIC-ACID VALUES OF COMMERCIAL PEACHES (SEASONS 1945–46 INCLUSIVE)

Variety	Number of samples	Percentage of samples in 3 milligram ascorbic-acid classes				Mode[1]	Average[1]
		0–2·9	3·0–5·9	6·0–8·9	9·0–11·9		
		%	%	%	%	mg.	mg.
All varieties	33	3·0	27·3	60·6	9·1	6·7	6·6
Elberta	2	—	50·0	50·0	—	—	6·1
J. H. Hale	6	—	66·6	33·4	—	5·0	5·8
Rochester	3	—	—	33·4	66·6	—	9·5
Valiant	6	—	16·7	66·6	16·7	7·5	7·2
Vedette	7	—	—	100·0	—	7·4	7·2
Veteran	6	16·6	50·0	33·4	—	5·0	5·1

[1] Ascorbic acid in milligrams per 100 grams of fresh edible portion.

Direct comparison of ascorbic-acid content of British Columbia peaches may be made with recent results of investigations on similar varieties of peaches grown in different areas of the United States. Kirk and Tressler (93) reported the following values obtained one season for the flesh of three varieties of peaches grown on the New York State Experiment Station, Geneva: Valiant, 8 mg.; Vedette, 12·0 mg.; and Veteran, 6·0 mg. These figures are 1 to 5 mg. higher than the average obtained for these varieties in this study where the fruit was analysed as received and eaten by the consumer. While not specifically stated, it is probable that the fruit employed by Kirk and Tressler was picked at optimum maturity and analysed almost immediately. Seasonal mean values found by Zielinski (171) for some peeled peaches grown at Corvallis, Oregon, in 1947, were as follows: Fisher, 2·32 mg.; Valiant, 4·64 mg.; Vedette, 2·70 mg.; Veteran, 2·77 mg. and J. H. Hale, 3·34 mg.; which are roughly one-half the average value found for the same varieties grown in the commercial peach areas of British Columbia.

Floyd and Fraps (67) reported Elberta peaches in Texas to range from 1·5 to 3·5 mg. with an average value of 2·2 mg. In a study on peaches being canned in California and the Pacific Northwest in 1946, Lamb, Pressley and Zuch (94) found Elberta to range from 6·3 to 8·0 mg. with an average of 7·0 mg. Schroeder, Satterfield and Holmes (140) found ripe Elberta peaches grown in a restricted area in North Carolina and assayed unpeeled and within 2 days of harvest, to contain 5·2 mg. In an extensive study on Washington State peaches during the seasons 1945-46, Neubert *et al.* (120) found ripened Elberta peaches to range from 3·1 to 5·5 mg. and J. H. Hale from 3·1 to 5·1 mg. These results were expressed on the original freshweight basis and not on the weight at time of analyses which would tend to slightly reduce the values given. On the other hand, the peaches were analysed with the skins on which would tend to make the ascorbic-acid values greater than if the fruit had been peeled as was done by the writers of this report. It may thus be seen that peaches grown commercially in British Columbia, while not yielding any outstanding values, are equal in vitamin C content to varieties grown elsewhere.

Neubert *et al.* (120) found little seasonal variation in the ascorbic-acid content of Elberta and J. H. Hale peaches which is in general agreement with the writers' findings on peaches. Neubert (120) also found only slight differences in the ascorbic-acid content of peaches picked at various stages of maturity

and was unable to confirm the work of Schroeder, Satterfield and Holmes (140) who found ripe peaches to contain considerably more ascorbic acid than greener fruits. While no systematic study on maturity was carried out by the writers, data obtained on commercial packages of peaches showing shipping maturity grade[1] indicated no significant difference in the ascorbic-acid content of the peaches due to maturity at harvest as prevailing under present commercial conditions of picking, which is in accord with Neubert *et al.* (120).

Kirk and Tressler (93) found the skins of peaches to contain two to four times as much ascorbic-acid per gram as the flesh. Schroeder *et al.* (140) also reported that the concentration of ascorbic acid in peaches is highest in the skin and decreases towards the pit, the skin containing about two times the vitamin C content of the flesh.

Wittwer and Hibbard (168) in Missouri, studying the vitamin C-nitrogen relation in peaches as influenced by fertilizers, found that excessive application of nitrogen fertilizer depressed the vitamin C content of peach fruits but that application of complete fertilizer only slightly reduced the ascorbic-acid content in the fruit and gave the highest yields of any treatment, thus supplying quality and an increased quantity of vitamin C per tree.

Zielinski (171) found marked varietal differences, particularly among the early and mid-season varieties but no significant differences due to time of harvest. He concluded that the production of vitamin C in peaches is largely under genetic control.

Pears

Seven samples of Bartlett (Williams' Bon Chrétien) and a few samples of Anjou (Beurre d'Anjou), Flemish Beauty and Winter Nelis varieties of pears were analysed, the results being tabulated in Tables 20 and 21. These limited determinations indicate that pears are a poor source of ascorbic acid averaging 3·9 mg. with minimum and maximum values respectively of 2·0 and 5·0 mg. Bartlett, of which the largest number of lots were tested, ranged in ascorbic-acid content from 3·3 to 4·2 with an average figure of 3·6 mg. There did not appear to be much variation between varieties.

Discussion.—A survey of the literature showed that pears are low in ascorbic acid which is in accord with the writers' results. Values reported by other investigators are: Fixsen and Roscoe (66) in a survey of world literature up to 1939, less than 1·0 to 10·4 mg.; Floyd and Fraps (67) in Texas, 2·1 to 3·1 mg., with an average of 2·5 mg.; Olliver (126) in England, 2·0 to 3·0 mg.; Argentine pears (5), an average value of 1·6 mg.; Sherman (143), 3 to 5 mg.; and compilations by Hewston and Marsh (80) and the United States Department of Agriculture (38) give respectively average values of 3 and 4 mg. for pears.

The ascorbic-acid values found in this investigation for Bartlett pears were similar to those published by Truscott *et al.* (160) for Ontario-grown fruit and those found by Fixsen and Roscoe (66) and Booher, Hartzler and Hewston (29) in their respective surveys. Values reported by Chu and Read (47) for this variety in China averaged about 1 mg. lower than that found in the present study. Tressler and Moyer (159) studying changes in vitamin C content of Bartlett pears grown in the State of New York, reported a value of 9·0 mg. for unpeeled fruit. Truscott *et al.* (160) in a limited study found Flemish Beauty and Howell varieties to contain 10·0 and 9·0 mg. respectively. On the whole, pear varieties grown in British Columbia compare very favourably with those grown in other areas.

[1] Long shipment maturity, i.e. take 6 to 10 days to ripen; short (local) shipment maturity, i.e. take 2 to 5 days to ripen.

TABLE 20.—ASCORBIC-ACID CONTENT OF COMMERCIAL PEARS (SEASONS 1945–46 INCLUSIVE)

Variety	Ascorbic-acid content in milligrams per 100 grams of fresh edible portion						
	1945		1946		Summary 1945–1946		
	Number of Samples	Average	Number of Samples	Average	Number of Samples	Average	Range
		mg.		mg.		mg.	mg.
All varieties	10	3·8	2	4·6	12	3·9	2·0—5·0
Anjou	2	4·8	1	5·4	3	5·0	4·7—5·4
Bartlett	6	3·6	1	3·8	7	3·6	3·3—4·2
Flemish Beauty	1	5·0	—	—	—	—	—
Winter Nelis	1	2·0	—	—	—	—	—

TABLE 21.—DISTRIBUTION OF ASCORBIC-ACID VALUES OF COMMERCIAL PEARS, PRUNES AND PLUMS (SEASONS 1945–46 INCLUSIVE)

Variety	Number of samples	Percentage of samples in 3 milligram ascorbic-acid classes		Mode[1]	Average[1]
		0–2·9	3·0–5·9		
		%	%	mg.	mg.
Pears					
All varieties	12	8·3	91·7	3·8	3·9
Bartlett	7	—	100·0	3·4	3·6
Prunes and plums					
All varieties	15	60·0	40·0	3·0	2·7
Italian prunes[2]	11	54·6	45·4	3·0	2·8

[1] Ascorbic acid in milligrams per 100 grams of fresh edible portion.
[2] Includes early strains—Greata, DeMaris and Fryer.

Prunes and Plums

Eleven samples of Italian prunes and single or duplicate lots of Bradshaw, Peach and Yakima plums were analysed during the years 1945-46. Data on prunes and plums are presented in Tables 21 and 22. It may be seen from these tables that Italian prunes and several varieties of plum are extremely low in ascorbic acid. Sixty per cent of the samples contained less than 3 mg. Values for Italian prunes ranged from 1·7 to 3·8 mg. Highest value obtained for any plum was 5·7 mg. found in the single sample of Yakima plum. No seasonal variation was noted in the ascorbic-acid content of Italian prunes for the two years, 1945 and 1946.

Discussion.—A review of the literature showed that the results of other investigations are in general agreement with those of the writers. Fixsen and Roscoe (66) in a survey of world literature up to 1939, reported that the ascorbic-acid content of plums ranged from less than 0·5 to 4·6 mg. Olliver (126) recorded figures of 1·0 and 4·6 mg. for English plums; Shatzlein and Fox-Timmling (137), 2·9 to 6·7 with an average of 4·6 mg. for German plums; and Mathiesen (109) reported the content of plums in Norway as 6 to 7 mg. Analyses performed by

TABLE 22.—ASCORBIC-ACID CONTENT OF COMMERCIAL PRUNES AND PLUMS (SEASONS 1945-46 INCLUSIVE)

Variety	Ascorbic-acid content in milligrams per 100 grams of fresh edible portion						
	1945		1946		Summary 1945–1946		
	Number of samples	Average	Number of samples	Average	Number of samples	Average	Range
		mg.		mg.		mg.	mg.
All varieties	7	2·9	8	2·5	15	2·7	1·1—5·7
Italian prunes[1]	7	2·9	4	2·6	11	2·8	1·7—3·8
Bradshaw plum	—	—	1	1·8	—	—	—
Peach plum	—	—	2	1·1	—	—	—
Yakima plum	—	—	1	5·7	—	—	—

[1] Includes early strains—Greata, DeMaris and Fryer.

Floyd and Fraps (67) on three varieties of plums grown in Texas showed a range in ascorbic acid from 2·0 to 10·7 mg. Fresh Argentine prunes have been reported to average 2·8 mg. (5).

In a recent study of Ontario fruit, Truscott *et al.* (160) analysed a large number of varieties of fresh plums and prunes, and found them to range in ascorbic-acid values from 2·0 to 7·0 mg. The number of published analyses of fresh Italian prunes is extremely limited, analyses being generally on the dried product. However, figures available are all in agreement that this fruit is a relatively very poor source of ascorbic acid.

CAROTENE CONTENT AND VITAMIN A VALUE OF B.C. TREE FRUITS

Two hundred and forty-nine samples of fruit were analysed for carotene during 1946 and 1947. The results are summarized for each kind and variety of fruit in Tables 23 to 29 inclusive. The distribution of carotene in 200 microgram classes for apricots and peaches is presented in Table 27. The approximate vitamin A values found for different kinds of fruit calculated in terms of International Units are given in Table 30.

Vitamin A values present a problem. The vitamin A value of foods is derived from preformed vitamin A per se and from vitamin A-active carotenoids (so-called "precursors") which may be converted in the small intestine (154) to vitamin A which the body requires. At least four substances (alpha-, beta-, and gamma-carotene, and cryptoxanthin) are known to be precursors of vitamin A. Fruits, like other plant foods, owe their vitamin A value to the carotene they contain, particulary beta-carotene. The latter has at least double the vitamin activity of the other carotenoids and usually comprises by far the greater percentage of the active carotene forms in fruits.

The efficiency of dietary carotene in meeting vitamin A needs is variable. It depends on many factors, some known, many unknown. Thus, the body may obtain considerably less than the theoretical yields of vitamin A from carotene as it occurs in plant foods. The Canadian Council on Nutrition (153) has indicated that three to five times as much carotene may be needed and believes that under practical conditions about four times as many International Units from carotene as of pure vitamin A are required to satisfy physiological needs. Sherman (143) stated that some conventional evaluations for purposes of food

planning have reckoned food carotene as furnishing to human nutrition only one-half its theoretical vitamin A value. The United States National Research Council Recommended Dietary Allowances (68) for vitamin A are based on the premise that approximately two-thirds of the vitamin A value of the average diet in the United States is contributed by carotene and that carotene has half, or less than half, the value of vitamin A. The true utilization or conversion relationship of carotene from each kind of various fruits and other plant foods, to vitamin A value in the human dietary under different conditions has yet to be established.

The problem is further complicated by the various chemical and biological methods of assay. Some investigators using chemical methods report figures for different kinds of carotenoids present, others report crude carotene or total carotenoids, and still others convert their figures to International Units. Total carotenoids undoubtedly yield too high a value. Generally, crude carotene has been considered also to yield high values but there are indications that this is not necessarily true (128). On the other hand some of the chemical results in the literature have been low because of incomplete extraction. Biological tests, accepted as the most reliable procedure, do not overcome all the difficulties as they are subject to variations and improvements in method of assay.

Because of these difficulties, the results of this study are reported in micrograms (mcg.) of beta-carotene, the form of carotene estimated by the methods employed. If further research in this field calls for revision in vitamin A values, the results reported here may readily be re-calculated. The carotene content of fruits found in this study may be converted to vitamin A value expressed in terms of International Units (I.U.) on the basis that by definition of the Biological Standardization Committee of the League of Nations, 1 International Unit of vitamin A is equivalent to 0·6 micrograms (·0006 milligrams) of beta-carotene. For comparative purposes, values reported in the literature were converted on the basis that 1 International Unit was equivalent to 0·6 micrograms of beta-carotene or 1·2 micrograms of other vitamin A active carotenoids.

The new dietary standard for Canada (153) sets the daily vitamin A maintenance allowance according to body weight for adults, body weight and age for children from 1 to 15 years, and additional allowances for pregnant and lactating women. The vitamin A is calculated in International Units in terms of carotene since it is considered by these authorities that most of the dietary vitamin A is consumed in the form of its precursor, carotene. Thus, for example, according to these standards a normal adult (male or female) of 120 pounds requires 4000 I.U. (2400 mcg. carotene); 140 pounds, 4600 I.U. (2760 mcg. carotene); 160 pounds, 5300 I.U. (3180 mcg. carotene); or 180 pounds, 5900 I.U. (3540 mcg. carotene). For purposes of evaluating the fruit as to its vitamin A value, an average figure of 5000 I.U. (3000 mcg. carotene) might be taken as an adult's daily requirement. When classifying the fruit as a dietary source of ascorbic acid, one contributing more than 50 per cent or 25 to 50 per cent of the daily allowance in a $3\frac{1}{2}$ ounce (100 gram) serving was classified respectively as "excellent", or "good". Fruit rated as "fair" or "poor" supplied respectively 12·5 to 25 per cent and 0 to 12·5 per cent. The same procedure was employed for evaluating fruits as to their vitamin A value on the basis of the 5000 I.U. (3000 mcg.) average daily requirement. Thus a fruit classified as "excellent" in vitamin A value would contribute in a $3\frac{1}{2}$ ounce (100 gram) serving more than 2500 I.U. (1500 mcg.); "good", 1250 to 2500 I.U. (750 to 1500 mcg.); "fair", 625 to 1250 I.U. (375 to 750 mcg.); and "poor", 0 to 625 I.U. (0 to 375 mcg.).

Apples

The results of the analyses of 106 samples of 23 varieties of apples for carotene are presented in Table 23. The values obtained ranged from 22 to 154 mcg. with a mean of 47 mcg. per 100 grams. Of the principal commercial

varieties the highest value, 61 mcg., was obtained on a sample of Golden Delicious. With the exception of the variety, Stirling, all apples showed a very low and narrow carotene content range of 22 to 61 mcg. with no significant varietal differences. The new variety, Stirling, had a maximum value of 154 mcg. with 5 out of 6 samples analysed containing more than 100 mcg. While these values are still low, they average more than twice the usual carotene content of apples, indicating perhaps limited possibilities of breeding apples of greater vitamin A value. Apples are classed as a poor source of vitamin A.

Discussion.—A review of the literature (29, 38, 66, 107, 115, 132, 143) indicated apples to range in vitamin A value, calculated as carotene, from about 24 to 60 mcg. with an average content of about 50 mcg. which is in agreement with the writers' results. No reports were found of apples exceeding 100 mcg. Thus the variety, Stirling, analysed in this study, containing more than 100 mcg. of carotene, is outstanding so far as apples are concerned. Unfortunately this variety has certain horticultural characteristics which make it unsatisfactory for commercial introduction.

TABLE 23.—CAROTENE CONTENT OF COMMERCIAL APPLES (1946)

Variety[1]	Number of samples	Carotene content in micrograms per 100 grams of fresh edible portion	
		Average	Range
		mcg.	mcg.
All varieties	99	47	22 —154
Principal commercial varieties			
Delicious	4	40	32 — 55
Delicious–Red Strains	9	41	27 — 59
Golden Delicious	5	48	25 — 61
Jonathan	7	38	26 — 52
Jubilee	4	33	22 — 46
McIntosh	10	45	32 — 60
Newtown	8	47	39 — 55
Rome Beauty	4	41	30 — 50
Spartan	7	36	25 — 40
Stayman	8	46	33 — 60
Wealthy	1	60	—
Winesap	3	55	45 — 60
Miscellaneous varieties			
Grimes Golden	2	46	45 — 47
Northern Spy	4	37	26 — 54
Spitzenberg	4	52	40 — 58
Stirling	6	116	86 —154
Wagener	6	46	38 — 56
Winter Banana	2	33	30 — 37
No. 3–1	1	29	—
No. 4–5	1	40	—
No. 4–8	1	50	—
No. 5–4	1	35	—
No. 5–6	1	25	—

[1] Varieties arranged alphabetically in each group.

Apricots

In Table 24 are presented the results of analyses of 49 samples of 11 varieties of apricots. The distribution of carotene values for several apricot varieties is given in Table 27.

The data show that apricots are very good to excellent in vitamin A value, ranging in carotene content from 700 to 4150 mcg. with an average of 1937 mcg. Marked varietal differences were noted. Wenatchee Moorpark, the leading

commercial variety in British Columbia, had the lowest carotene content averaging 1207 mcg. with minimum and maximum figures of 700 and 2050 respectively. Sixty-five per cent of the samples contained 700 to 1100 mcg. On the other hand, English Moorpark, a variety of rather limited production, was very rich in carotene varying from 2400 to 4150 mcg. with most lots exceeding 2900 mcg.

Fig. 9. The apricot is a highly nutritious fruit. It is especially rich in vitamin A value.

Blenheim (Royal), Perfection, Rose and Tilton were all very similar in carotene content, ranging from 1500 to 2800 mcg. which makes these varieties approximately midway between Wenatchee Moorpark and English Moorpark in vitamin A potency. Eighty per cent of the Blenheim samples exceeded 2100 mcg. of carotene. Single-sample determinations of the new varieties developed at the Experimental Station, Summerland, namely, Leslie, Reliable and No. 27-5 indicate these fruits have carotene contents similar to Blenheim and Tilton. The Kaleden variety was found to have the same values as Wenatchee Moorpark.

Discussion.—In a survey of published data prior to 1940, Fixsen and Roscoe (66) reported fresh apricots to range from 1800 to 2300 mcg. per 100 grams. Sherman (142) in 1941 gave the probable range recalculated to micrograms as 2400 to 4800 mcg. Morgan (115) indicated a mean value of 3036 mcg. More recently Hewston and Marsh (80) reported a single figure of 2400 mcg. and Lamb, Pressley and Zuch (94) found values ranging from 810 to 2140 mcg. with an average figure of 1590 mcg. A recent United States Government publication of tables on food consumption (38) credits apricots with a vitamin A value of 1674 mcg. of carotene. Italian grown apricots are reported by investigators, Baccari and Maranelli (16) to average 677 mcg.

It is thus apparent that British Columbia apricots compare very favourably with those from other areas with respect to vitamin A value and are a rich source of this essential dietary constituent. Blenheim, Tilton, Perfection and especially English Moorpark were found to be particularly high in vitamin A value.

Cherries

Results of analyses for carotene content of sweet cherries are presented in Table 25. The 1946 samples were pitted, heated quickly to 212°F. (100°C.) in

TABLE 24.—CAROTENE CONTENT OF COMMERCIAL APRICOTS (1946)

Variety	Number of samples	Carotene content in micrograms per 100 grams of fresh edible portion	
		Average	Range
		mcg.	mcg.
All varieties	49	1,937	700 — 4,150
Blenheim (Royal)	10	2,225	1,550 — 2,800
English Moorpark	5	3,490	2,400 — 4,150
Kaleden	4	1,462	800 — 2,050
Leslie[1]	1	1,850	—
Perfection	2	2,300	2,100 — 2,500
Reliable[1]	1	2,450	—
Rose	2	2,200	1,750 — 2,650
Tilton	9	1,944	1,500 — 2,350
Wenatchee Moorpark	14	1,207	700 — 2,050
No. 27-5[1]	1	2,150	—

[1] New varieties.

a stainless steel, steam-jacketed kettle, filled immediately into cans leaving no headspace in the container, sealed, cooled and stored for several months at 32°F. (0°C.) until analysed. This procedure apparently reduced the carotene content. Only about one-half the carotene value was found in these canned lots compared with samples analysed in the fresh state the following year.

The data in Table 25 show fresh cherries to contain only small quantities of carotene ranging from 46 to 90 mcg. with an average value of 62 mcg. There was no apparent varietal difference between Bing, Lambert and Royal Ann varieties. The single sample of the new variety, Van, yielded the highest carotene figure of 90 mcg. Cherries, like apples, are a poor source of vitamin A.

Discussion.—A review of the limited published data on carotene and vitamin A value of sweet cherries revealed that cherries are definitely low in this constituent. Booth (31) reported cherries to vary from 100 to 200 mcg. and Sherman (143) indicated a range of 120 to 258 mcg. With respect to these figures, no information was given as to varieties but probably the data included sours as well as sweet cherries. Very early work by Potter and Dickson (133) in 1933 listed the provitamin A content of frozen sweet cherries as follows: Royal Ann, 160 mcg.; Bing, 95 mcg.; Deacon, 60 mcg.; and Lambert, trace. Hewston and Marsh (80) gave a single value of 30 mcg. Booher and Marsh (30) found the Windsor variety of cherries grown in Maryland and purchased on the local market to contain less than 48 mcg. calculated as carotene but determined by biological assay. Sweet cherries grown in Argentine are reported to average 87 mcg. (5).

Peaches

Twenty-three samples of 9 varieties of peaches were analysed during 1946. The results are presented in Tables 26 and 27. The average for all varieties was 788 mcg. with minimum and maximum values of 313 and 1463 mcg. respectively.

The carotene content of peaches varied considerably with variety. The two later maturing varieties, Elberta and J. H. Hale, contained only about half as

TABLE 25.—CAROTENE CONTENT OF COMMERCIAL CHERRIES (1946-1947)

Variety	Number of samples	Carotene content in micrograms per 100 grams of fresh edible portion	
		Average	Range
		mcg.	mcg.
Fresh fruit (1947)			
All varieties	7	62	46 — 90
Bing	2	53	52 — 54
Lambert	2	62	48 — 76
Royal Ann	2	58	46 — 70
Van	1	90	—
Canned solid packed fruit (1946)			
All varieties	17	33	25 — 55
Bing	5	32	25 — 44
Deacon	1	52	—
Lambert	8	31	30 — 55
Royal Ann	1	25	—
Van	1	40	—
Victor	1	35	—

much carotene as most of the other varieties. Perhaps climatic conditions are marginal in the British Columbia fruit area for consistent optimum development of carotene and quality in these late maturing varieties. Valiant and Vedette varieties, averaging 1197 and 1013 mcg. respectively, were consistently higher than other varieties. Mean values obtained for Veteran, Rochester, Fisher and the new introductions, Spotlight and Superior, ranged from 715 to 875 mcg. Rochester and Veteran both showed a relatively wide range in carotene content with differences between extremes of 612 and 1125 mcg. respectively. Differences noted between extremes for other varieties where 3 or 4 samples were analysed, was less than 400 mcg. A greater number of samples for each variety would have yielded more conclusive varietal data.

Fifty-seven per cent of all peach samples analysed exceeded 700 mcg. with 9 per cent greater than 1300 mcg. Excluding the varieties, Elberta and J. H. Hale, 75 per cent of the peaches exceeded 700 mcg. and 12 per cent had carotene values greater than 1300 mcg. Thus it is seen that peaches may be classified as fair to very good in vitamin A potency.

Discussion.—The following values have been reported in the literature from the United States for carotene and vitamin A value of several varieties of yellow fleshed peaches: Fitzgerald and Fellers (63), 180 to 1800 mcg.; Sherman (143), 600 to 1200 mcg.; Morgan (115), 798 mcg. average figure; Hewston and Marsh (80), 1020 mcg.; DeFelice (56), 720 to 1140 mcg. The recent United States Government tables of food composition (38) give a vitamin A value for peaches of 528 mcg. when calculated as carotene. White fleshed peaches are reported to contain negligible quantities of carotene. A report from the Argentine (5) placed the average value for peaches at 433 mcg.

The writers found Valiant and Vedette to be very good sources of carotene. Values obtained for the Valiant, Vedette, Veteran and Rochester varieties were

TABLE 26.—CAROTENE CONTENT OF COMMERCIAL PEACHES (1946)

Variety	Number of samples	Carotene content in micrograms per 100 grams of fresh edible portion	
		Average	Range
		mcg.	mcg.
All varieties	23	788	313 — 1,463
Elberta	2	425	375 — 475
Fisher	1	715	—
J. H. Hale	4	439	313 — 600
Rochester	4	744	463 — 1,075
Spotlight	1	775	—
Superior	1	875	—
Valiant	4	1,197	1,025 — 1,401
Vedette	3	1,013	850 — 1,250
Veteran	3	784	338 — 1,463

in general agreement with those reported by DeFelice (56) who found the following carotene contents in New York grown peaches: Valiant, 720 mcg.; Veteran, 1140 mcg.; Rochester, 792 mcg.; Elberta, 792 mcg.; and J. H. Hale, 768 mcg. per 100 grams of peeled sliced fruit. On the other hand, values obtained for J. H. Hale and Elberta grown in British Columbia were approximately half those reported by DeFelice (56) and Booher and Marsh (30). However, the British Columbia values are very similar to those found by Neubert *et al.* (120) for J. H. Hale and Elberta peaches in the State of Washington. These investigators determined carotene as crude carotene and total carotenoids. For comparative purposes their data were recalculated on the basis that approximately 38 per cent of the crude carotene of peaches was composed of beta-carotene. This procedure yielded values for ripened Elberta of 403 to 578 mcg. and J. H. Hale of 334 to 521 mcg.

Mackinney *et al.* (101), working with some California-grown fresh freestone peaches, estimated total carotenoid on a moisture-free basis as follows: Elberta, 0·0154 per cent; Muir, 0·0171 per cent; and Lovell, 0·025 per cent. They stated that beta-carotene could be sufficiently precisely estimated as 10 per cent of the total carotenoid in the fresh peach. Thus, employing this correction factor and recalculating to a normal fresh-fruit moisture content, the corresponding carotene figures were found to be as follows: Elberta, 209 mcg.; Muir, 224 mcg.; and Lovell, 327 mcg. These values are lower than those determined in this study or given by other investigators. The data of Mackinney *et al.* indicate that in the case of peaches many vitamin A values reported in the literature which have been determined chemically may be seriously over-estimated. On the other hand, DeFelice (56) found animal bioassay values to agree within experimental limits with chemical evaluation of the vitamin A content of peaches. Also, Booher and Marsh (30) employing the rat-growth method of biological assay found ripe peeled and pitted Elberta peaches grown in Maryland to contain 1670 I.U. of vitamin A per 100 grams. If this vitamin A activity is assumed to be entirely beta-carotene then these Elberta peaches contained 1002 mcg. of carotene which is considerably more than that determined by procedure of Mackinney *et al.*

TABLE 27.—THE DISTRIBUTION OF CAROTENE VALUES OF COMMERCIAL APRICOTS AND PEACHES (1946)

Variety	Number of samples	Percentage of samples in 200 microgram carotene classes												
		300–499	500–699	700–899	900–1,099–	1,100–1,299	1,300–1,499	1,500–1,699	1,700–1,899	1,900–2,099	2,100–2,299	2,300–2,499	2,500–2,699	2,700–2,899	Over 2,900
		%	%	%	%	%	%	%	%	%	%	%	%	%	%
Apricots															
All varieties	49	—	—	10·2	10·2	—	6·1	10·2	10·2	8·2	18·4	6·1	6·1	6·1	8·2
Blenheim (Royal)	10	—	—	—	—	—	—	20·0	—	—	40·0	10·0	10·1	20·0	—
English Moorpark[1]	5	—	—	—	—	—	—	—	—	—	—	20·0	—	—	80·0
Tilton	9	—	—	—	—	—	—	11·1	33·4	22·2	22·2	11·1	—	—	—
Wenatchee Moorpark	14	—	—	28·5	36·0	—	14·2	7·1	—	7·1	7·1	—	—	—	—
Peaches															
All varieties	23	30·4	13·0	17·4	17·4	13·0	8·8	—	—	—	—	—	—	—	—
All varieties, excluding Elberta and J. H. Hale	17	11·8	11·8	23·6	23·6	17·6	11·8	—	—	—	—	—	—	—	—

[1] Only variety analysed which exceeded 2,900 mcg. per 100 grams. It is an old variety of limited commercial value.

Neubert *et al.* (120) found that crude carotene and total carotenoid content of peaches increased during the ripening period, especially at higher temperatures. However, they did not find in either the harvest-maturity study or ripening study the best quality in samples that developed the highest total carotenoid content with longer ripening and at higher temperatures. No definite correlation was established in the present investigation between fruit ripened from "white"[1] or "pink"[2] shipping maturity grade and the final carotene content in the ripened fruit.

DeFelice (56) showed that peeling of peaches resulted in an average loss of approximately 25 per cent in provitamin A content. He also found that heat processing reduced the vitamin A values about 50 per cent but that freezing caused very little loss. These results were confirmed recently by Neubert *et al.* (120) with only small variations. In limited tests, the writers observed that canning of peach pulp reduced the provitamin A content about 50 per cent.

Pears

In Table 28 is recorded the carotene content found for the four main commercial varieties of pears, namely, Bartlett, Flemish Beauty, Anjou (Beurre d'Anjou) and Bosc (Beurre Bosc), grown in British Columbia. The mean value for all varieties analysed was only 12 mcg. with minimum and maximum figures of 5 and 15 mcg. respectively. There was no significant difference within or between varieties. The data show pears to be very poor in vitamin A value.

Discussion.—The results obtained in this study are in full agreement with other investigators. Manville *et al.* (106) listed average values of 5 mcg. for Bosc and 6 mcg. for Anjou and Winter Nelis. Sherman (143) gave 6 to 12 mcg. as the range for pears while Morgan (115) indicated a mean value of only 6 mcg. Booher and Marsh (30) reported a sample of Bartlett pears to contain less than 30 mcg. as determined by the biological assay method. Recent United States

TABLE 28.—CAROTENE CONTENT OF COMMERCIAL PEARS (1946)

Variety	Number of samples	Carotene content in micrograms per 100 grams of fresh edible portion	
		Average	Range
		mcg.	mcg.
All varieties	8	12	5 — 15
Anjou	1	10	—
Bartlett	5	11	5 — 15
Bosc	1	9	—
Flemish Beauty	1	10	—

Government tables of food composition (38) rate pears at 12 mcg. which is identical with the average value obtained in this study on British Columbia fruit.

Prunes and Plums

The results of analysis of 6 samples of fresh Italian prunes (standard and early strains) and a total of 5 lots of Bradshaw, Peach and Yakima plums for carotene content are recorded in Table 29. Italian prunes were found to have carotene values ranging from 600 to 1100 mcg. with an average figure of 758 mcg.

[1] Long shipment maturity, i.e. take 6 to 10 days to ripen.
[2] Short (local) shipment maturity, i.e. take 2 to 5 days to ripen.

There was no apparent difference in carotene content between standard Italian prunes and the three early strains analysed, Greata, DeMaris and Fryer. The single lot of Yakima plum contained 575 mcg. Bradshaw and Peach plums were much lower in carotene with values around 175 to 330 mcg. Thus, while Italian prunes are good in vitamin A value, plums generally are poor.

Fig. 10. The Italian prune is a flavourful fruit with very good nutritive properties.

Discussion.—There are very few published data on the vitamin A value or carotene content of fresh prunes. Almost all the estimations for this vitamin have been made on the dried product. Evaluation of such data recalculated to average moisture content of fresh fruit indicated values similar to those obtained by the writers. It also was difficult to determine from the literature not only what variety was analysed but whether it was a "prune" or "plum". Morgan (114) indicated fresh prunes to contain 600 mcg. or more of carotene;

TABLE 29.—CAROTENE CONTENT OF COMMERCIAL PRUNES AND PLUMS (1946)

Variety	Number of samples	Carotene content in micrograms per 100 grams of fresh edible portion	
		Average	Range
		mcg.	mcg.
All varieties	10	585	175 — 1,100
Italian prune[1]	6	758	600 — 1,100
Bradshaw plum	1	175	—
Peach plum	2	275	220 — 330
Yakima plum	1	575	—

[1] Standard and early strains.

Wolff (170) in Germany gave a value of 250 mcg. for prunes while a report from Argentine (5) stated prunes to contain 383 mcg. Mackinney *et al.* (101) found fresh Imperial prunes in California to contain 0·0041 and 0·0037 per cent beta-carotene on a moisture-free basis. By calculation, these Imperial prunes at normal moisture content of fresh prunes contained 655 to 726 mcg. of carotene which is close to the average found for British Columbia Italian prunes.

Fresh plums according to Booth (31) range from 100 to 400 mcg. of carotene per 100 grams. Morgan (115) indicated plums to have no vitamin A value. However, other reports (30, 143) gave values of about 210 mcg. for plums. These values are in general agreement with the results of this investigation.

Vitamin A Values in Terms of International Units

Table 30 summarizes in terms of International Units the approximate vitamin A values of the various fruits as determined in this investigation. This information was prepared as a ready reference for those primarily interested in the probable dietary vitamin A value of British Columbia fruits as consumed.

According to the classification system adopted in this report, the kinds of fruits in general may be rated for vitamin A value as follows: apricots—excellent; peaches and prunes—good; plums—fair to poor; cherries and apples—poor; and pears—very poor.

TABLE 30.—APPROXIMATE VITAMIN A VALUES OF COMMERCIAL BRITISH COLUMBIA TREE FRUITS EXPRESSED IN TERMS OF INTERNATIONAL UNITS[1]

Kind of fruit[2]	Number of samples	Vitamin A value in International Units per 100 grams of fresh edible portion	
		Average	Range
		I.U.	I.U.
Apples	99	78	37 — 257
Apricots	49	3,228	1,167 — 6,917
Cherries	7	103	77 — 150
Peaches	23	1,313	522 — 2,438
Pears	8	20	8 — 25
Plums	4	—	292 — 958
Prunes	6	1,263	1,000 — 1,833

[1] Compiled from previous tables. Carotene values converted into International Units on the accepted basis that one I.U. of vitamin A is equivalent to 0·6 micrograms (·0006 mg.) of beta carotene.

[2] Apricots, cherries, plums and prunes were stemmed and pitted; peaches were peeled and pitted; apples and pears were cored but not peeled.

STATUS OF KNOWLEDGE ON NUTRITIVE VALUE OF FRUIT

The investigation reported here provides a complete picture of the composition and dietetic value of the more important varieties of tree fruits grown commercially in British Columbia, as far as can be determined at present by chemical means and current knowledge of nutritive factors. However, the knowledge of nutrition is not static and no doubt other factors are present awaiting discovery. It is possible that additional information of value regarding the dietetic and health-promoting properties of fruits might be secured by biological research involving the use of animals and humans. Studies employ-

ing human subjects should prove particularly beneficial. It is highly desirable that further experimental proof be obtained concerning certain physiological and therapeutic properties attributed to various fruits. Such work should be undertaken at a reliable institution properly equipped with the necessary trained personnel teams of investigators and laboratory facilities to conduct this expensive and highly specialized type of research.

SUMMARY

This report presents the results secured during five years' investigation of the nutritive value of British Columbia tree fruits as revealed by their chemical composition. Many hundreds of analyses were made of the more important varieties of apples, apricots, cherries, peaches, pears, plums and prunes grown in the Okanagan and adjacent valleys. The results are given in detail with discussions for each kind of fruit.

In general it may be stated that the investigation showed British Columbia tree fruits to compare very favourably with, and in a few instances to be superior to, similar fruits grown elsewhere with respect to nutritive value. This is particularly noteworthy since the analyses were performed on fruit from commercial packages as received and used by the consumer and not on fruit as freshly harvested, specially treated or selected. Hence the data indicate the composition of fruits as they normally reach the consumer.

Mention is made of the direction in which future research into the nutritive, physiological, and therapeutic properties of fruit might proceed.

In order to add to the value of this bulletin as a comprehensive reference work on the composition and nutritive value of British Columbia tree fruits, an appendix is included giving additional relevant information.

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APPENDIX

I. Energy Value of Fruits

TABLE 31.—AVERAGE ENERGY VALUE (FUEL OR CALORIE VALUE) OF TREE FRUITS OF THE KIND GROWN IN BRITISH COLUMBIA[1,2]

Fruit	Fuel value in Calories per 100 grams of fresh edible portion
	Calories
Apples	58
Apricots	51
Cherries	72
Peaches	47
Pears	63
Plums	50
Prunes	83

[1] Calorie values (physiological energy values) were calculated from the analytical data of Chatfield and Adams (44) according to the recommendations of the Committee on Calorie Conversion Factors of the Food and Agriculture Organization of the United Nations (51).

[2] Estimation of approximate Calorie value of British Columbia tree fruits per 100 grams may be made by multiplying the per cent total solids content given in this bulletin in the tables of proximate composition for various fruits, by the factor 4.

APPENDIX

II. Mineral Components of Fruits

TABLE 32.—SOME MINERAL COMPONENTS OF FRESH FRUITS (FROM DATA RECORDED IN THE LITERATURE)[1]

Fruit	Estimated in milligrams per 100 grams of fresh edible portion													
	Calcium	Magnesium	Potassium	Sodium	Phosphorus	Chlorine	Sulphur	Iron	Copper	Manganese	Iodine [2, 3]	Fluorine [4]	Aluminum [3]	Zinc [3]
	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Tree fruits of the kind grown in British Columbia														
Apples	7	6	116	10	11	4	5	0·3	0·071	0·084	0-Trace	0·007	0·047	0·04
Apricots	15	9	279	30	24	2	6	0·5	0·120 [5]	—	—	—	—	0·04
Cherries	17	14	246	3	22	3	8	0·5	0·070 [5]	—	0	—	3·490	—
Peaches	9	11	256	15	18	5	7	0·6	0·050 [5]	—	—	—	0·880	0·02
Pears	13	9	129	8	16	4	7	0·3	0·134	0·064	0	0·004	—	0·16
Plums	17	11	232	4	20	2	5	0·5	0·080	0·096	0·0017	—	—	0·03
Prunes (Italian or Fellenberg variety)	14 [6]	9 [6]	176 [6]	2 [6]	12 [6]	1 [6]	1·5 [6]	1·3 [6]	(0·10) [3]	0·525 [6]	—	—	1·400 [4]	—
Some other commonly consumed fruits														
Bananas	8	31	373	42	28	125	12	0·6	0·200	0·642	—	—	—	0·28
Blueberries	16	10	65	16	20	8	11	0·9	0·110 [3]	5·227 [3]	—	—	—	—
Grapefruit	17	10	198	4	18	3	8	0·3	0·060 [5]	—	—	0·003	—	—
Grapes	17	7	254	11	21	2	9	0·6	0·098	0·083	—	—	—	0·12
Lemons	21	9	148	13	12	4	8	0·3	0·130 [5]	0·038 [3]	—	—	—	0·17
Oranges	30	10	181	10	19	4	8	0·3	0·076	0·025	—	0·005	0·088	0·17
Pineapple	16	11	214	14	11	46	7	0·3	0·080 [5]	—	—	—	—	0·26
Raspberries	40	23	190	3	37	22	18	0·9	0·210 [5]	0·690 [3]	—	—	—	—
Strawberries	22	12	145	7	22	11	12	0·9	0·075	0·219	—	—	—	0·09

[1] Average values. Data adapted from Sherman (143) unless otherwise noted. Parentheses are used to denote probable values.
[2] Campbell and Young (41). Plum value determined only for Bradshaw variety, recalculated from p.p.b. dry weight basis to fresh weight basis (85% moisture). Trace represents approximately 3·7 p.p.b. or 0·00037 mg. per 100 grams, fresh weight basis.
[3] Winton and Winton (167).
[4] Clifford (49) (flesh).
[5] McCance and Widdowson (100).
[6] Jones and Bullis (87). Data on dried flesh (14·2% moisture) of Western Oregon Italian prunes, recalculated to average fresh fruit basis of 82% moisture.

APPENDIX

III. Vitamin Values of Fruits

As previously indicated in this bulletin, fruits are important as a source of ascorbic acid (vitamin C) and carotene (vitamin A value), and in some instances contain appreciable amounts of niacin. Fruits also contribute small quantities of the other known vitamins with the exception of vitamin D which appears to be absent from fruits. With respect to a group of substances termed "vitamin P" which may play an important role in nutrition (43), fruits apparently are the richest sources. Plums are reported to be a moderate to good source, cherries a moderate source, and apples a poor source.

Additional information on the vitamin content of British Columbia fruits and similar or other fresh fruits commonly eaten in Canada is summarized in Tables 33 and 34.

TABLE 33.—VITAMIN A VALUE AND ASCORBIC-ACID CONTENT FOUND FOR BRITISH COLUMBIA TREE FRUITS COMPARED WITH VALUES GENERALLY REPORTED IN THE LITERATURE FOR SIMILAR AND OTHER FRESH FRUITS COMMONLY EATEN IN CANADA

Fruit	Vitamin content per 100 grams of fresh edible portion							
	Vitamin A value				Ascorbic acid content			
	British Columbia		Literature		British Columbia		Literature	
	Average	Range	Average	Range	Average	Range	Average	Range
	I.U.	I.U.	I.U.	I.U.	mg.	mg.	mg.	mg.
Tree fruits of the kind grown in British Columbia[1]								
Apples	78[2]	37 — 257[2]	80	40 — 100	7·8[3]	1·2 — 20·9[3]	5	1 — 20
Apricots	3,228	1,167 — 6,917	2,800	1,100 — 8,000	8·8	2·8 — 14·6	4	1 — 13
Cherries	103	77 — 150	—[4]	50 — 430	9·4	1·1 — 24·8	9	1 — 17
Peaches	1,313	522 — 2,438	1,300	300 — 3,000	6·6	2·2 — 11·0	6	1 — 12
Pears	20	8 — 25	20	8 — 20	3·9	2·0 — 5·0	4	2 — 5
Plums	—	292 — 958	350	0 — 600	2·4	1·1 — 5·7	4	1 — 7
Prunes[5]	1,263	1,000 — 1,833	—	1,000 +	2·8	1·7 — 3·8	—	—
Some other commonly consumed fruits[6]								
Bananas	—	—	—	160 — 430	—	—	10	8 — 14
Blueberries	—	—	—	100 — 280	—	—	16	7 — 22
Grapefruit	—	—	Trace	Trace — 21	—	—	41	35 — 45
Grapes	—	—	—	20 — 80	4[7]	1 — 7[7]	4	3 — 5
Lemons	—	—	0	0 — Trace	—	—	50	40 — 60
Oranges	—	—	190	50 — 400	—	—	52	40 — 60
Pineapple	—	—	—	40 — 130	—	—	—	7 — 25
Raspberries (Red)	—	—	(130)[4]	—	—	23 — 28[7]	23	8 — 38
Strawberries	—	—	—	60 — 90	—	56 — 89[7]	53	40 — 80

[1] Literature data adapted from references given in text on discussion of ascorbic acid and vitamin A values for tree fruits of the kind grown in British Columbia.
[2] Main commercial varieties averaged 74 I.U. and ranged from 37–102 I.U.
[3] Main commercial varieties averaged 6·9 mg. and ranged from 1·2–17·1 mg.
[4] "Dash" is used where no data available or insufficient to indicate average value or range. Parentheses are used to denote probable values obtained from limited studies.
[5] Italian or Fellenberg variety.
[6] Literature data for these fruits adapted from following references: 35, 38, 61, 76, 80, 98, 111, 115, 136, 143, 144, 145, 166. The range given does not represent maximum-minimum values, but the more normal variation which may be expected in commercially consumed fruit.
[7] Atkinson, Strachan, and Moyls (14). Limited sampling of raspberries and strawberries.

TABLE 34.—B COMPLEX VITAMIN CONTENT OF SOME FRESH FRUITS (FROM DATA RECORDED IN THE LITERATURE)[1]

Fruit	Estimated in micrograms per 100 grams of fresh edible portion									
	Thiamine		Riboflavin		Niacin (Nicotinic acid)	Pantothenic acid	Pyridoxine (Vitamin B_6)	Biotin	Inositol	Folic acid
	Average	Range	Average	Range						
	mcg.	mcg.	mcg.	mcg.	mcg.	mcg.	mcg.	mcg.	mcg.	mcg.
Tree fruits of the kind grown in British Columbia										
Apples	34	19 — 96	18	5 — 73	50 — 500	50 — 60	26	0·9	24,000	8
Apricots	30	25 — 35	40	40 — 90	136 — 700	—	—	—	—	—
Cherries	51	—	(20)	—	127 — 400	—	—	—	—	—
Peaches	20	14 — 70	50	40 — 64	300 — 900	170	16	1·7	96,000	17
Pears	20	20 — 95	40	7 — 150	91 — 140	—	—	—	—	—
Plums	150	48 — 200	(30)	25 — 44	118 — 600	—	—	—	—	—
Prunes (Italian or Fellenberg variety)[2]										
Some other commonly consumed fruits										
Bananas	76	50 — 160	60	23 — 84	464 — 600	180	320	4	34,000	95
Blueberries	(30)	30 — 45	(70)	—	(300)	—	—	—	—	—
Grapefruit	50	40 — 150	(40)	20 — 100	136 — 200	290	7 — 27	3	150,000	55
Grapes	50	30 — 67	30	9 — 60	200	—	—	—	—	—
Lemons	40	30 — 90	Trace	0 — 73	100 — 190	—	—	—	—	—
Oranges	81	66 — 96	30	15 — 90	173 — 300	70 — 340	80	1·9 — 10	210,000	83
Pineapple	80	63 — 125	(25)	20 — 80	136	—	—	—	—	—
Raspberries (Red)	30	20 — 40	(70)	—	(300)	—	—	—	—	—
Strawberries	30	21 — 30	70	21 — 70	220 — 300	260	44	4	60,000	23

[1] Adapted from the following sources: Adams and Smith (1), American Can Company (3), Booher and Hartzler (28), Booher and Marsh (30), U.S. Dept. Agr. Publ. (38), Cheldelin and Williams (46), Hewston and Marsh (80), Hodson (83), Morgan (115), Sherman (143, 144).

Parentheses are used to denote probable values. Dashes are used where no data were available but where reason to believe that future research will show a measurable amount of a nutrient to be present.

With the possible exception of thiamine, there is a paucity of data for a given B vitamin in many of the fruits. While the figures in this table have been selected as the best available data, many of the values, particularly for pantothenic acid, pyridoxine, biotin, inositol and folic acid (pteroylglutamic acid) will need revision as methods are further refined and additional data are reported from quantitative systematic studies. Hence at best the concentrations given for these latter vitamins are only indicative.

[2] No data available on the fresh raw fruit. Dried prunes (several varieties) reported to have the following values per 100 grams of edible portion: thiamine, 100–200 mcg.; riboflavin, 50–350 mcg.; niacin, 1,700 mcg.

APPENDIX

IV. Effect of Climate and Cultural Practices on Nutritive Value of Fruits

Chemical composition of fruit tends to be an inherent characteristic of the kind and variety of fruit but may be modified by climate and cultural practices. Certain fruits tend to be always a good source of some nutritive factors while others are poor. Thus apricots are always very rich in provitamin A, peaches and prunes very good, while cherries, apples and pears are low to insignificant. While sometimes there is little variation between varieties of any one kind of fruit, the variation can be quite marked. Althought the nutritive constituents may be affected to some extent by season or other factors, the varieties tend to maintain their relative position. Thus in apples, Wagener and Northern Spy are consistently high in ascorbic-acid content, while McIntosh is always low; in cherries usually Lambert is good in ascorbic-acid content while Bing is poor.

The nutritive value is influenced by climate and to a lesser degree by cultural practices, location, and soil conditions. A favourable climate and good cultural practices enhance not only the appearance and flavour of the fruit, but also its nutritive value. Sunshine and moderately warm temperatures promote maximum development of sugar and vitamin content. This accounts for some yearly and sectional variations. If the soil is deficient in minerals the fruit also tends to be lower than normal in these constituents. Horticultural practices affect the composition of the fruit. For example, the maturity of the fruit when harvested affects the sugar and acid content and flavour but has little effect on the vitamin content. Too early harvesting results in fruit which is lower in sugar, higher in acid, and higher in tannin or astringent characteristics, than is the case when picking is done at the proper stage of maturity.

APPENDIX

V. Effect of Processing on Nutritive Value of Fruits

In connection with the project on the manufacture of juices and purees from British Columbia tree fruits, analyses have been made to determine the retention of nutritive value. Vitamins are the only constituents which are likely to be lost. Where sugar is added to the product, its nutritive properties are enhanced to this extent. Preliminary results indicate that at least 50 per cent of the provitamin A contained in the fresh fruit is retained in peach and apricot purees. These products are thus still good to very good sources of vitamin A. Even if diluted 1 to 1 as in the making of nectars, they supply good amounts of this vitamin. Future work will be directed to increasing the vitamin A value of these products since some of the factors affecting it are not known.

APPENDIX

VI. Relationship of Total Sugar Content to Soluble Solids by Refractometer

The soluble solids reading on the refractometer of the expressed juice or pulp of the fruit gave values very close to the true soluble solids estimated by official methods. During this investigation the average difference between the values obtained by the two methods for soluble solids did not exceed 1 per cent and usually was less than 0·5 per cent. Furthermore, for each kind of fruit, a

consistent relationship was found to exist between the actual total sugar content and the soluble solids reading by refractometer. These data are presented in Table 35. Only very slight variations were noted for different varieties of the same fruit. Also, some variations occurred with degree of maturity and ripeness, the sugar making up a slightly greater percentage of the soluble solids in the more mature fruit of any one variety.

TABLE 35.—RELATIONSHIP OF TOTAL SUGAR CONTENT TO SOLUBLE SOLIDS READING BY REFRACTOMETER

Kind of fruit	Total sugar	Soluble[1] solids by refractometer	Percentage sugar of soluble solids	Number of samples analysed
	%	%	%	
Apples	11·51	13·49	85·3	67
Apricots	7·01	11·61	60·4	30
Cherries	13·56	21·17	64·0	38
Peaches	8·87	12·09	73·3	48
Pears	9·49	13·60	69·6	24
Prunes, Italian	9·87	15·87	62·2	14

[1] Refractometer equipped with a sugar scale reading in percentage by weight standardized at 68°F. (20°C.). Readings recorded as soluble solids.

APPENDIX

VII. Physiological and Therapeutic Properties of Fruit

The investigation reported in this bulletin was concerned entirely with the determination of the chemical composition of British Columbia tree fruits. Such information is of primary importance in consideration of the dietary and nutritive value of any food product. No studies or reviews were made of the physiological properties, clinical or therapeutic uses of fruits although brief reference was made to a few of these properties in the preliminary discussion of the constituents of fruit and their relation to nutritive value and health. There are many publications in the medical and biological literature of North America and Europe dealing with this aspect. That fruits have medicinal properties and uses has been proved by clinical investigations, particularly in the treatment of certain intestinal disturbances. Much more evidence is required before the mode of action or exact mechanisms involved can be determined.

Besides the definite food values which can be accurately measured, fruits provide important esthetic characteristics such as palatability, variety of flavour and colour, aroma and eye appeal, which are of great importance in nutrition. These factors are difficult to evaluate quantitatively but most certainly contribute materially to the pleasure of eating and the effective assimilation of food.

For those who are interested in this subject so far as it is known today, the following few references, many of which contain fairly extensive bibliographies, are suggested for initial consultation: American Medical Association Council on Foods (4); Bergeim, Hanszen and Arnold (20); Charley and Harrison (42); Cruess (52); Esselen, Fellers and Gutowska (59); Manville (104, 105); Sherman (143, 144); and Todhunter (156).

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