

# VITAMIN C CONTENT OF BALDWIN APPLES AND APPLE PRODUCTS<sup>1</sup>

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## INTRODUCTION

In spite of the importance of apple as a food, only a few investigations of its vitamin C content have been reported. A study of the literature failed to reveal any data bearing on the important Baldwin variety. Nor have apple cider and other apple products been carefully evaluated for vitamin content. Although Bracewell, Hoyle, and Zilva (1)<sup>2</sup> found that the Bramley Seedling variety grown in England protected 300-g guinea pigs when fed at a daily level of 3 g, Van Leersum and Hoogenboom (9), Givens, McClugage, and Van Horne (6, 7), Kohman, Eddy, and Carlsson (8), Hessler and Williams (reported by Campbell (4, p. 68)), and Hessler and Craig (reported by Campbell, (3, p. 67-68)) found that the protective amounts of various varieties of apples varied from 10 to over 40 g. At the present time the apple is not generally considered a particularly good source of vitamin C.

This paper presents the first results of a study now being made of the important apple varieties of the Northeast and the effect of various factors upon the vitamin content of apples and of products manufactured from apples.

## VITAMIN C IN SPRAYED AND UNSPRAYED APPLES

In 1932, Nelson and Mottern (10) reported that lead arsenate sprays applied to orange trees considerably reduced the vitamin C content of the fruit. Since apples are almost universally sprayed with arsenic compounds and other toxic substances for insect and fungus control, comparisons were made in the present investigation between sprayed and unsprayed Baldwin apples. The apples for the experiment were obtained from orchards at Haydenville, Mass., and from the college orchard at Amherst, Mass. The usual spray schedule was followed, lime-sulphur and lead arsenate being used. The college orchard received eight and the Haydenville orchard seven sprays. The season was dry, hence there was a considerable spray deposit on the sprayed fruit when it was picked. From 0.005 to 0.008 grain of  $As_2O_3$  per pound of fresh fruit was found on the sprayed fruit, but the unsprayed showed merely a trace of arsenic. The sprayed fruit was a deeper red and of better quality than the unsprayed. However, only sound fruits were used in the feeding experiments. The apples were stored at 36° F. until the test was concluded. Examination was begun in October, 1931, immediately after harvest.

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<sup>2</sup> Reference is made by number (*italic*) to Literature Cited, p. 1045.

The quantitative animal feeding method of Sherman, La Mer, and Campbell (11) was followed, except that the guinea pigs were fed in proportion to their weight; that is, if an animal weighing 300 g received 3 g of apple daily, one weighing 400 g would receive 4 g of apple. This method is believed to be fairer than feeding the same weight of food regardless of the animal's weight. At least three animals housed in individual wire cages, were used for every test. Radial sectors of apples were fed because of the variation in vitamin C content in different parts of the apple (2, 5).

The basal ration consisted of 58 per cent equal parts of rolled oats and wheat bran, 30 per cent of vitamin-C-free baked milk powder,

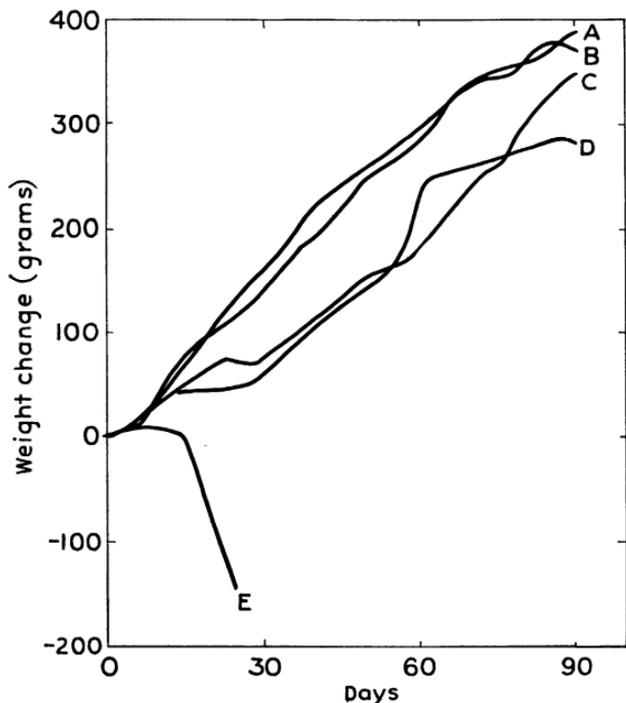


FIGURE 1.—Results of feeding guinea pigs sprayed and unsprayed Baldwin apples from Haydenville and Amherst, Mass., as the sole source of vitamin C: A, 4 g sprayed apple (Haydenville) fed daily, scurvy score, 0; B, 5 g sprayed apple (Amherst) fed daily, scurvy score, 0; C, 5 g unsprayed apple (Amherst) fed daily, scurvy score, 0; D, 4 g unsprayed apple (Haydenville) fed daily, scurvy score, 0; E, negative control, scurvy score, 10

10 per cent butterfat, 1 per cent each of cod-liver oil and salt. This basal ration and water were kept before the animals at all times. However, the guinea pigs were forced to derive all their vitamin C from apples or apple products.

At the end of the feeding period all animals were chloroformed and carefully examined for lesions of scurvy. Negative controls died in from 26 to 33 days with an average Sherman scurvy score of 16. A normal animal has a score of 0, while the maximum for extremely severe scurvy is 24.

The significant data are presented graphically in Figure

1. Apples from trees carefully sprayed all season are fully as rich in vitamin C as apples from unsprayed trees. In fact, the animals receiving sprayed fruit showed slightly larger weight gains than those receiving the unsprayed. Four grams daily of either sprayed or unsprayed Baldwin apples per 300-g guinea pig gave excellent weight gains and full protection from scurvy.

Two additional series of animals were fed 7 g of sprayed and unsprayed Baldwin apples from Amherst. The average weight gains per animal after 90 days were 381 and 430 g respectively, and there was no evidence of scurvy at autopsy. The data thus show no decrease of vitamin C in the sprayed fruit. In fact in two of the three tests the sprayed fruit appeared to contain slightly more vitamin C than the unsprayed.

## VITAMIN C IN APPLES STORED FOR DIFFERENT LENGTHS OF TIME

Sprayed Baldwin apples grown on the college farm and stored at 36° F. were used to determine the effect of storage on vitamin C. The examinations for vitamin C were made in October immediately following harvest, after 3 to 5 months in storage, and finally after 8 to 10 months. Figure 2 shows the results obtained.

Four grams of fresh apple possessed approximately the same anti-scorbutic potency as 5 g of 4-months-old apple or 6 g of 9-months-old fruit.

Similarly, 3 g of apple in storage 4 months gave better growth and protection than 4 g after 9 months. After 9 months the loss in vitamin C was about 33 per cent. Baldwin apples apparently retain a substantial part of their vitamin C for several months; that is, during the season in which they are eaten in largest quantities. Bracewell, Kidd, West, and Zilva (2), and also Van Leer-sum and Hoogenboom (9) found no loss in vitamin C of apples during storage, but Hessler and Craig, as reported by Campbell (3), found a loss of fully 30 per cent in Jonathan apples held in storage about 5 months.

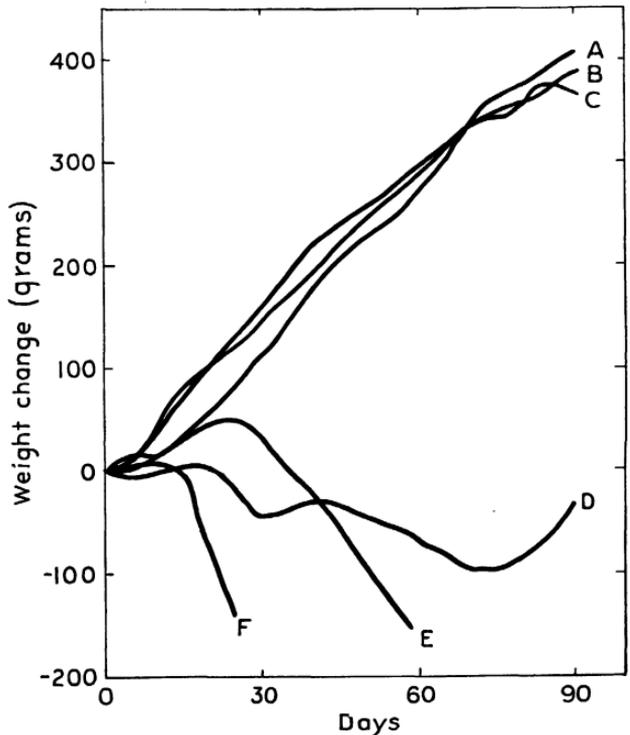


FIGURE 2.—Effect of storage on the vitamin C content of Baldwin apples as shown by the results of feeding them to guinea pigs as the sole source of vitamin C: A, 6 g apple stored 9 months fed daily, scurvy score, 0; B, 4 g fresh apple fed daily, scurvy score, 0; C, 5 g apple stored 4 months fed daily, scurvy score, 0; D, 3 g apple stored 4 months fed daily, scurvy score, 5; E 4 g apple, stored 9 months fed daily, scurvy score 13; F, negative control, scurvy score, 10

## VITAMIN C IN APPLE JUICE AND PRESERVED CIDER

Apple juice was extracted daily from sprayed Baldwin apples which had been in storage 9 months and whose protective dose was approximately 6 g. The small centrifugal extractor shown in Figure 3 was used to extract the juice. The yield of juice averaged 70 to 80 per cent of the weight of the apple. The juice was pale green in color when first extracted but oxidized to a deep yellowish brown after 24 hours.

By the use of a hydraulic press cider was prepared from the apples that had been in storage at 36° F. for 4 months. Guinea pigs fed 5 g daily of these apples were fully protected from scurvy. The cider was divided into two portions. One was heated to 170° F. and allowed

to settle at 36° for 12 hours, siphoned into pint bottles, sealed with crown caps, and pasteurized for 20 minutes at 160°; the other was benzoated by adding sodium benzoate sufficient to give a concentration in the cider of 0.1 per cent. Both lots were stored in 1-pint bottles at 36°. It was necessary to make up a second batch of benzoated cider after the experiment had been in progress 40 days. The effect

of feeding this freshly prepared cider is evident by the marked rise in Figure 5, C, at the 40 to 45 day interval. All juices and cider were fed by pipette, so that each animal received a known amount each day. (Fig. 4.)

The significant data are presented in Figure 5.

The animals receiving 9 g (not shown in fig. 5) and 6 g daily of freshly extracted apple juice were well protected against scurvy and showed large gains in weight. Three grams of the fresh juice, however, did not afford protection. Since 6 g of the whole apples afforded protection, it appears that freshly extracted juice is practically as rich in vitamin C as the apple itself. Nine grams of 1-day-old juice also afforded full



FIGURE 3.—Small centrifugal extractor used in preparing the apple juice

protection, showing that the juice retains a substantial part of its vitamin C for at least 24 hours. Lesser amounts were not evaluated.

Pressed cider differs from extracted cider in both appearance and flavor. There is greater opportunity for oxidation to take place in the pressed product. The benzoated cider possesses moderate antiscorbutic properties for several days after manufacture but gradually loses this property on storage. Eight grams fed daily failed to support growth or give protection from scurvy. Probably 10 to 15 g would have been required. As pointed out previously, the temporary upward trend after 40 days in Figure 5 indicates increased growth as a result of feeding freshly prepared cider. No animal fed 4 g daily survived for more than 60 days.

Pasteurized eider when fed at the 8-g level showed practically no protective value and was little better than the negative controls. There is a marked loss in vitamin C when Baldwin apples are manufactured into benzoated or pasteurized eider. Unless the juice is freshly extracted from apples, it is likely to contain but little vitamin C.

#### VITAMIN C IN CANNED APPLE SAUCE

The vitamin C content of two kinds of Baldwin apple sauce was determined. Unstrained, "lumpy" or rough sauce, was prepared from peeled and cored fruit. The waste was 23 per cent. Sugar equivalent to 18.7 per cent of the weight of prepared apples and water equivalent to 13 per cent was added and the sauce was cooked in a loosely covered kettle for 6 minutes. Since the yield was exactly the weight of the prepared apples, 10 g of the finished sauce was practi-

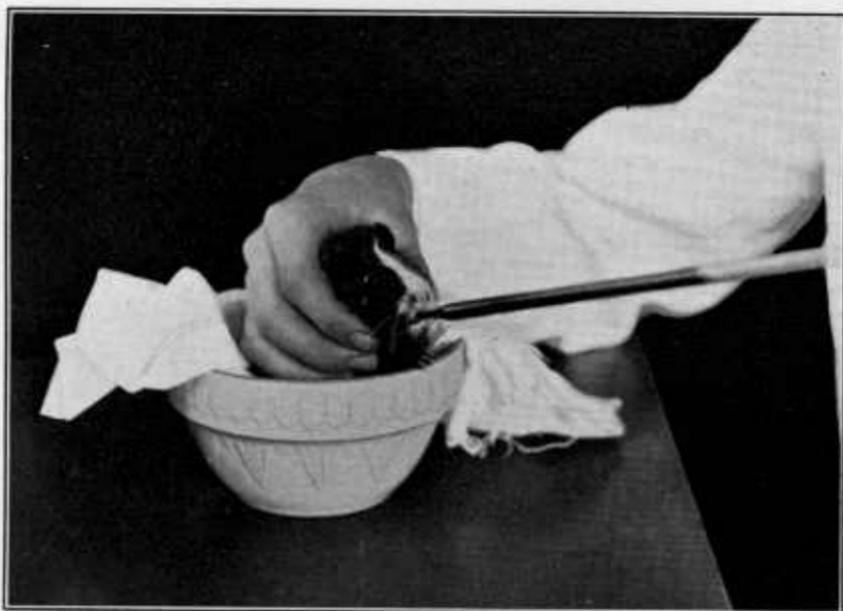


FIGURE 4.—Pipette method of feeding apple juice and eider to guinea pigs

cally equivalent to 8 g of apple. The sauce was packed into half-pint jars, pasteurized at 170° F. for 20 minutes, and immediately cooled.

The smooth or strained apple sauce was prepared by cooking quartered unpeeled Baldwin apples until soft. Twelve per cent by weight of water was added before cooking. The mass was pulped while hot in a tomato pulper, 19 per cent sugar was added, and the sauce was packed hot into half-pint glass jars and pasteurized at 170° F. for 25 minutes. The sauce was stored at 36° until used, a new jar being opened every other day. Most of the guinea pigs ate the sauce greedily; those that did not were eliminated from the experiment. The graphs representing the collected data are shown in Figure 6.

In general, canned apple sauce does not retain much of the vitamin C of the fresh apple. Strained sauce, even when fed at 10-g levels

was little better than the negative control. Certainly the quantity of strained apple sauce necessary to protect against scurvy would be

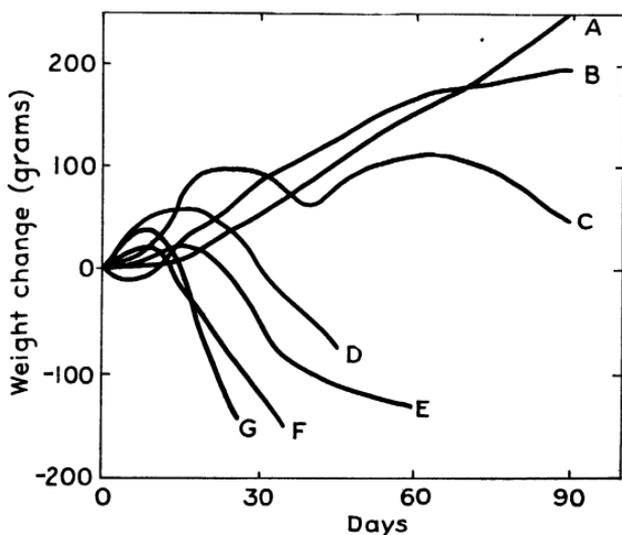


FIGURE 5.—Results of feeding guinea pigs Baldwin apple juice and apple cider as the sole source of vitamin C: A, 9 g 1-day-old apple juice fed daily, scurvy score, 0; B, 6 g fresh apple juice fed daily, scurvy score, 1.5; C, 8 g of benzoated cider fed daily, scurvy score, 10; D, 3 g fresh apple juice fed daily, scurvy score, 10; E, 4 g benzoated cider fed daily, scurvy score, 14; F, 8 g pasteurized cider fed daily, scurvy score, 14; G, negative control, scurvy score, 10

very high. The unstrained sauce was somewhat richer in vitamin C, but as much as 10 g was not nearly enough to protect the animals against scurvy or to maintain their weight. Neither style of sauce, as prepared in this experiment, can be considered of appreciable antiscorbutic value. These results are in accord with those of Hessler and Williams (4), who found that Johnathan apple sauce contained practically no vitamin C, and with those of Koh-

man, Eddy, and Carlsson (8) who obtained similar results with Yellow Newtown (Albemarle Pippin) and Stayman Winesap.

#### SUMMARY

The Baldwin apple grown in Massachusetts is a good source of vitamin C, about 4 g per 300 g of body weight sufficing to maintain growth in guinea pigs and to protect them fully from scurvy.

In two tests, apples from completely sprayed trees contained as much or possibly more vitamin C than apples from unsprayed trees.

In 4 to 6 months of storage at 36° F. Baldwin apples lost about 20 per cent of their vitamin C content; in 8 to 10 months the loss was nearly 40 per cent.

Freshly expressed Baldwin apple juice was found to be nearly as rich in vitamin C as the fresh apple. Little loss occurred during the

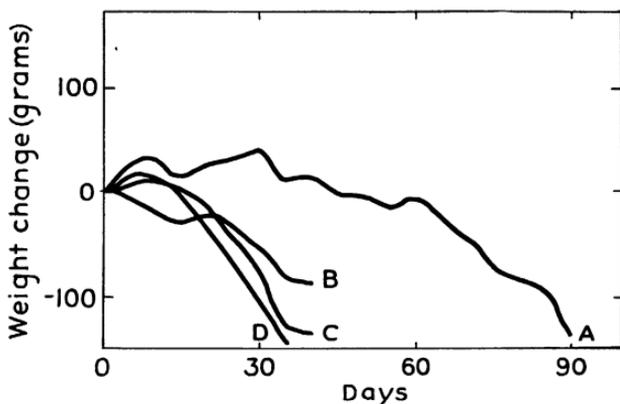


FIGURE 6.—Results of feeding guinea pigs Baldwin apple sauce as the sole source of vitamin C: A, 10 g unstrained apple sauce fed daily, scurvy score, 9; B, 5 g unstrained apple sauce fed daily, scurvy score, 13; C, 10 g strained apple sauce fed daily, scurvy score, 14; D, 5 g strained apple sauce fed daily, scurvy score, 14

first 24 hours after extraction. Benzoated or pasteurized ciders over 48 hours old, however, failed to retain an appreciable quantity of vitamin C.

Canned Baldwin apple sauce, either strained or unstrained, proved to be a poor source of vitamin C. The unstrained sauce was somewhat superior to the strained.

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