Studies on the Bio-Pigments and Vitamins : IV. Correlative Changes in the Carotene, Total Carotenoids and the Other Constituents of Sweet Potatoes during Storage (I)

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Introduction

Several workers have studied the effect of storage on the carotene content of sweet potatoes. The results obtained varied widely, some reporting an increase(1), some a decrease(2), and others no significant change.(3) Several factors may be responsible for the varying results. Experimental conditions may alter the behavior of the roots; inadequate control of these conditions may lead to erroneous conclusions. Loss of weight through loss of both moisture and dry matter may cause an apparent increase in carotene. Determination of percentage of moisture only reveals little about the absolute loss of either moisture or dry matter. Additional information on the absolute loss in weight during storage is necessary to determine whether an apparent increase in carotene is real or only apparent.

In the previous paper(1) the authors have reported briefly an increase in carotene during the period of storage and data were presented showing the identification of the carotenoid pigments found in sweet potatoes. The present studies are an attempt to determine if there is a real increase in carotene during storage, and if so, to clarify the relationship between the changes in the carotene, total carotenoids, moisture and starch content of sweet potatoes during storage.

Materials and Methods

Three varieties of sweet potatoes were used in this study: Kagoshima 7-1061, the deepest red colored variety (K-variety); Hayato, an intermediate type (H-variety); Nōrin No. 2, the palest variety (N-variety). Of these three varieties, K-variety contained the highest carotene content, H-variety an intermediate and N-variety the lowest at harvest.

The sweet potatoes used in this study were grown at the Sweet Potato Laboratory, Division of Crop II, Kyushu Agr. Exp. Sta., Murasakibaru, Kagoshima, in 1956. The plants were set on May 18 and were harvested on November 19. The roots were washed to remove adhering soil dried and weighed individually; the weight of each root in grams was recorded on the root with a magic ink, and reweighed at time of sampling. This proved a satisfactory method for determining loss of weight. The analytical data can then be calculated back to the weight at harvest, and the results can be reported on the harvest weight basis.

Samples for the analyses were stored in a wood-box, in the bottom of which rice-straws were spread, at room temperatures (av. 13.6°) without curing. The stored samples were analyzed at about one month intervals from November 19 in 1956 to February 20 in 1957.

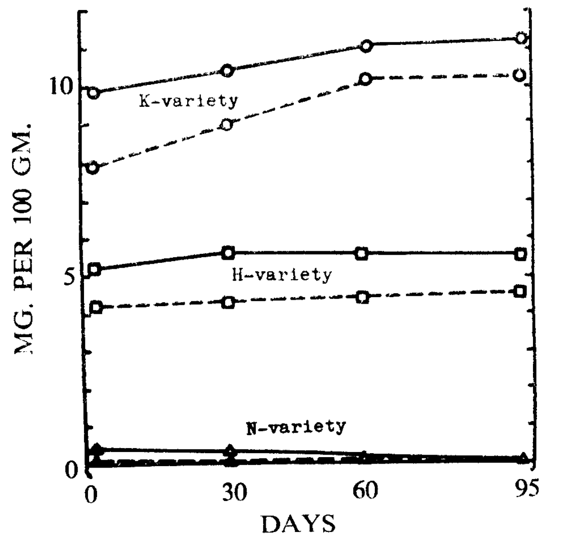
To insure that the results obtained were not due to individual root variations, each variety and treatment was composed of 10 replicates of five roots each. Each sample was taken in duplicate and consisted of a composite of half of each of five unpeeled roots, split lengthwise, mashed and mixed thoroughly befor sampling. The results of the duplicates were averaged and the amount reported is the average of the 10 replicates.

The A.O.A.C. Method(5) was used in extracting the total carotenoid pigments and determining the carotene. The total pigments were determined from the petroleum ether extract before chromatographing, and the carotene after chromatographing. Both were read in a spectrophotometer with a 450mμ in petroleum ether and their contents were calculated using $E^{1\%}_{1cm}=2430$(6).

The moisture content was determined according to the usual method, in which drying at 105° was taken. The starch content was determined by the semi-micro Bertrand Method(7).

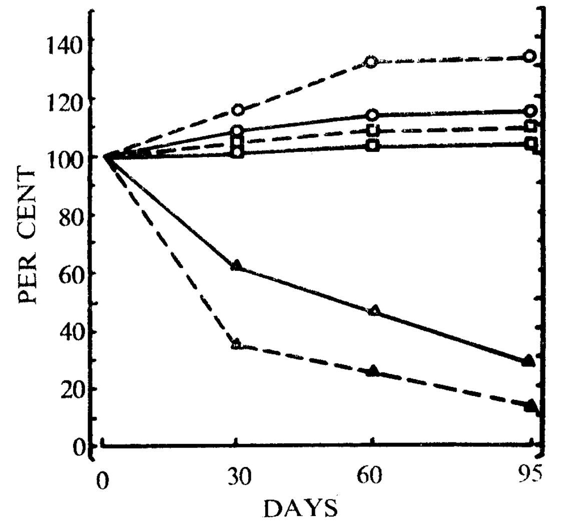
Results

The changes in the carotene and total carotenoids content of three varieties of sweet potatoes during storage are given in Fig. 1 and 2. From these results, it is evident that



——TOTAL PIGMENTS. ----CAROTENE.

Fig. 1. Changes in the carotene and total carotenoid pigments of sweet potatoes during storage



○ Kagoshima 7-1061. □ Hayato. △ Nōrin No. 2.
——TOTAL PIGMENTS. ----CAROTENE.

Fig. 2. Ratio of remains of the carotene and total carotenoid pigments of sweet potatoes during storage

the carotene and total carotenoid pigments content are the highest in K-variety, an intermediate in H-variety and the lowest in N-variety, both at harvest and through the storage period. Both K- and H-variety showed an increase in carotene and total carotenoids during storage and instead only N-variety showed a pronounced decrease. The percentages of increase in total carotenoid pigments and carotene of K-variety after three months in storage were 11.6 and 31.7%, respectively and those of H-variety 1.5 and 8.1%, whilst N-variety contained only 30% as much total carotenoids and 14% as much carotene at that time as it had at harvest.

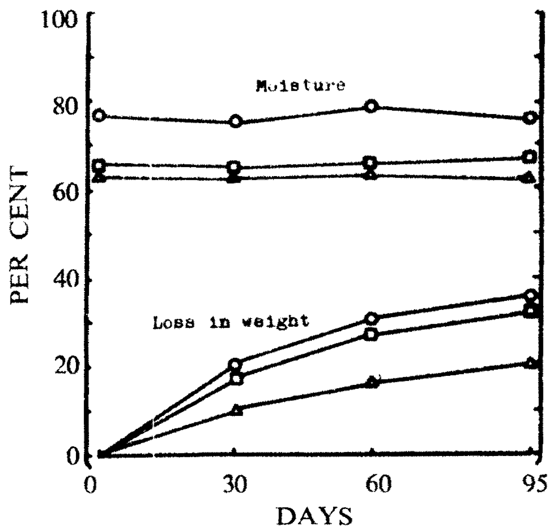
The ratio of carotene to total carotenoids of sweet potatoes during storage is shown in Table I, in which the different varieties are listed from up to down, in order of increasing

Table I. The ratio of carotene to total carotenoid pigments of sweet potatoes during storage

Variety	Carotene/total carotenoids × 100 Storage times (days)			
	0	30	60	95
Kagoshima 7-1061	80.6	86.5	93.6	92.0
Hayato	79.2	76.8	78.5	83.6
Nōrin No. 2	33.3	22.2	21.5	11.6

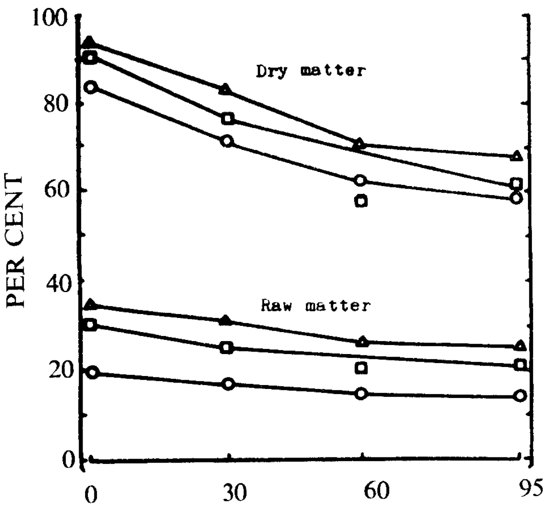
color intensity and K-variety presents the highest ratio throughout the storage period. The post-harvest increases are also primarily carotene as evidenced by the higher percentage figures during storage.

In addition to the changes in total carotenoid pigments and carotene content some other effects during storage were noted. The moisture content and the loss in weight of three varieties during storage at room temperatures are shown in Fig. 3. Judging from this result, it seems likely that the variety of sweet potatoes plays an important part in the moisture content: that of three varieties (K-, H-, N-variety) at harvest was 76, 65 and 62.5 % respectively and there was little change in the moisture content through three months in storage. This finding is in good agreement with the other workers' results(8,9). Instead there was a loss in weight, and especially early in the storage period a pronounced decrease. Loss in weight was determined as described under Materials and Methods. Such relative loss in weight also seems to be a varietal characteristic to some extent, and is probably associated with rate of respiration. Although the percentage of moisture was relatively constant during storage (Fig. 3), K-variety stored at room temperatures had lost approximately 34% in weight during the period of three months in storage as compared with 31% for H-variety, and 20% for N-variety. It is evident that much of the loss in weight of the roots stored is often due to loss of moisture, and loss of dry matter used in respiration is also of importance. Since the dry matter of sweet potatoes consists primarily of starch, the change in starch content during storage was simultaneously observed. The result obtained is shown in Fig. 4 where the starch contents at harvest are also influenced by the variety of sweet potatoes; those of three varieties (K-, H- and N-variety) were 20, 31 and 34% at harvest, respectively. They have gradually decreased during storage and after the period of three months in storage K-variety had lost approximately only 6% in starch content on the raw matter basis as compared with 9.5% for H- and N-variety.



○ Kagoshima 7-1061. □ Hayato. △ Nōrin No. 2.

Fig. 3. Changes in the moisture and loss in weight of sweet potatoes during storage



○ Kagoshima 7-1061. □ Hayato. △ Nōrin No. 2.
Fig. 4. Changes in the starch content of sweet potatoes during storage

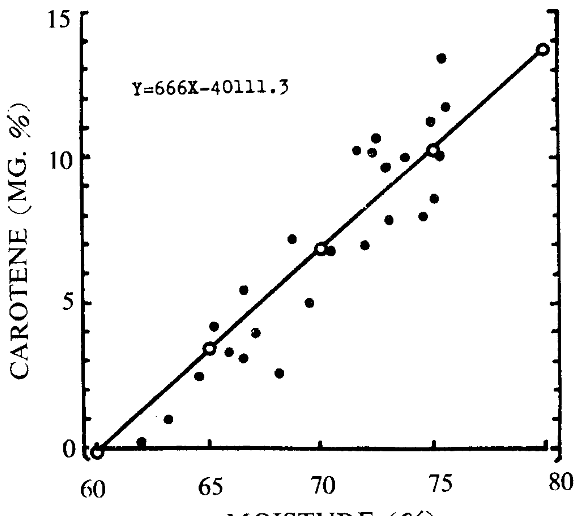


Fig. 5. Correlation between moisture and carotene content of the colored sweet potato varieties

Discussion

Up to now, it is well known that the starch content of sweet potatoes is closely related with their moisture content[10,11], and several simplified rapid methods are proposed, the principle of which consists of pressuming the starch content by determining the moisture content. From the results of our studies, it was found that there was a tendency for sweet potato variety containing high carotene in amount to be also high in moisture content (Fig. 1 and 3). Therefore, there may be a possibility that an analogous correlation exists between the carotene and moisture content. From this point of view, the authors studied on a relationship between carotene and moisture content of the yellow or red colored varieties of sweet potatoes at the time of harvest.

The samples used in this study were harvested late in October in 1956, and 10 varieties of sweet potatoes were used for this analysis: Hayato, Kyushu No. 12, Kagoshima 7-1038, 7-1046, 7-1049, 7-1057, 7-1058, 7-1059, 7-1061 and Nōrin No. 2. The results obtained are shown in Fig. 5 where the formula ($Y=666X-40,111.3$) is applicable only in the case of the same growing conditions, and therefore, it is needless to say that the numerical values in the formula should be changed in the case of the different growing conditions. In addition, a special regard must be paid to the fact that the samples should be analysed immediately after harvest, because the carotene content varies widely during storage, although the percentage of moisture was relatively stable during storage (Fig. 3).

Similarly, there may be a possibility that some any correlation exists between carotene and starch content of sweet potatoes. But, the further studies were not performed on this subject.

A discussion for the biosynthesis of the carotene will be attempted from the results obtained (Fig. 1 and 4), on the basis of carotene increase in amount and starch decrease during the storage period. Murimanoff[12] has reported that in box leaves the carotenoid synthesis appears to be associated with an increased lipid production and the disappearance of starch.

In the case of the sweet potatoes, it is generally considered that the carotene is synthesized and at the same time destroyed in the root itself during storage. And therefore, the rate of synthesis, as well as the rate of destruction is an important factor and the final result is dependent upon the algebraic sum of the two processes. Judging from the fact that all varieties of the sweet potatoes used in this study except N-variety have increased carotene content during storage in our experimental conditions, it would be suggested that the enzyme systems necessary to the carotenogenesis exist in the root itself and the rate of carotene synthesis was greater than that of its destruction. In this respect, a following problem must be elucidated; what may be a precursor of either carotene or carotenoid pigments? There seems to be a possible explanation for the above question: a part of starch would be split into a water-soluble monosaccharide such as glucose, subsequently being utilized for either carotene or carotenoid pigments synthesis via the tricarboxylic acid cycle. However, the full explanation of this must await further work.

Summary

The changes in the carotene, total carotenoid pigments, moisture and starch content, and the loss in weight of sweet potatoes were observed during the period in storage.

Three varieties of sweet potatoes were used: Kagoshima 7-1061 (K-variety); Hayato (H-variety); Nōrin No. 2 (N-variety).

The results may be briefly summarized as follows:

(1) Both K- and H-variety showed a real increase in carotene and total carotenoids content during storage in the present conditions, whilst only N-variety, a pronounced decrease.

(2) The rate of carotene formation during storage in K- and H-variety was more rapid than that of either total pigments or noncarotene pigments.

(3) The moisture content was relatively constant throughout the storage period. The average percentages of moisture were 74% in K-variety, 65% in H-variety and 62% in N-variety.

(4) There was, however, the loss in weight and especially early in the storage period a pronounced decrease. The K-, H- and N-variety had lost approximately 34, 31 and 20% in weight during the period of three months in storage, respectively.

(5) The starch contents have gradually decreased during storage and K-variety had lost about only 6% as compared with 9.5% for H- and N-variety during the same period.

(6) In addition, a correlation between carotene and moisture content of the yellow colored varieties was studied and the formula ($Y = 666X - 40,111.3$), which was applicable only in the given conditions, was proposed.

(7) Lastly, a speculation regarding the carotene formation in the root during storage was made briefly.

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