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EFFECT OF POSTHARVEST TREATMENTS AND STORAGE CONDITIONS ON AVOCADO FRUIT RIPENING AND QUALITY

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Abstract

Most of the common postharvest handling procedures are of a physical nature and are applied before, during or after the cold storage period. Variations in cold storage technologies, in combination with changes in storage atmosphere such as controlled atmosphere (CA) and modified atmosphere (MA), are reviewed. Some attempts to reduce chilling injuries are discussed. Physiological aspects of avocado ripening and quality, including involvement of some related enzymatic activities, are considered.

Key index words

Avocado, postharvest, storage, ripening, quality, chilling injury, ACC-oxidase.

1. Introduction

The main objective of postharvest treatments of avocado fruit is to present good quality fruit to consumers in markets which may be far away from the growing regions. However, there is no complete and objective definition of quality for avocado. Quality is a matter of location: The US standards for Floridian avocado are different from the "California Food and Agricultural Code" for avocado, and the Israeli standards are different from both of the American ones. Only recently was an OECD international standard established. If we look at it as Wills et al. (1981) did, "...quality depends on the position of the recipient in the distribution chain." we shall attempt to address quality criteria from the consumers' outlook, in which the general appearance (including size, color, shape, firmness and absence of defects) is usually the most important quality factor for most people. The texture, or firmness, is the next most important factor, after which come taste and flavor and, last, the nutritional value of the fruit. Consumers on the export markets in Europe, Japan or Canada buy avocado more for aesthetic reasons than for the calories or vitamins it contains.

In this review-lecture we shall try to discuss mainly subjects which were proposed for presentation by the participants this congress, assuming that people have suggested the most important issues which are now on the agenda for avocado postharvest studies.

2. Fruit maturity determination

The moment of harvest is the beginning of the postharvest life of the avocado fruit, but before that a decision has to be made about the readiness, or maturity, of the fruit for harvest. Because of the special nature of the avocado fruit, we are used to calling "maturation" - the processes occurring up to harvest and "ripening" - the syndrome of events taking place in the fruit after harvest, of which softening is the most obvious one. The great natural variability of avocado fruit is a serious problem which was addressed in several presentations at this congress.

The question when to start harvesting avocado fruit is a commercial one. The desire to come to the markets with fruit as early as possible has generated much research to determine the right maturity for harvest for the different varieties. Oil content is regarded as a most important factor in the taste of avocado fruit. To date, maturity determination for commercial purposes employs destructive methods which are based on either oil content or dry matter, which are highly correlated. The ideal situation would be to determine fruit maturity nondestructively, on the tree, before harvest.

In the early 1980s we developed, together with Karl Norris from Beltsville, Maryland, a nondestructive method for oil content determination using near infrared (NIR) technology with a one-of-a-kind set-up which he had in his laboratory. This method was not published. An attempt by a company in the USA to produce a commercial portable instrument based on the same NIR technology, failed. Two presentations at this meeting which described new nondestructive approaches to determine ripening state (and maybe even maturity), join attempts using other methods which were discussed and then published following a workshop held in 1993 (Brown and Sarig, 1994).

3. Postharvest handling

The harvesting, handling and transportation to the packinghouse and all operations conducted there, must be done carefully, in order not to cause mechanical damage. Any injuries would later accelerate ripening and spoil the appearance of the peel with blemishes and browning phenomena during and after storage. When we pull or snap a fruit instead of clipping, we wound it; likewise, rough handling may result in browning. Some fruits are more susceptible to handling blemishes than others and it is possible that preharvest factors are involved; however, that subject is not within the scope of this paper. Most postharvest treatments are done in order to delay the onset of ripening and to slow down the natural processes of the physiological deterioration of the fruit.

3.1. Prestorage treatments

Waxing may be regarded as a cosmetic treatment, as it imparts glossiness, but it has also pronounced physiological effects, especially on the internal atmosphere and weight loss of the fruit (Durand et al., 1984). A gain of 1 or 2 days of shelf-life may be achieved, but in some cases at the expense of development of more fruit rots. Similar results (with even longer shelf-life) were reported, in a poster presentation at this congress for N,O-carboximethyl chitosan.

The use of methyl bromide is being phased out and low temperatures are being introduced for disinfestation purposes. Postharvest fungicide applications were reported in the past, but they are not used commercially in Israel and we do not have any information about the use of fungicides as a routine commercial postharvest treatment in other countries. However, in reports at this meeting, from New Zealand, Australia and Israel, prochloraz was used experimentally.

Acclimation is being used successfully in South Africa, where it is called "temperature management" the fruit temperature being reduced gradually (Vorster et al.,1990).

Heat-shock prestorage treatments between 37 and 46ºC were reported at this congress in two presentations. However, they are not yet ready for commercial application.

In our Department (Pesis et al., 1994), low-oxygen atmosphere prestorage treatments (3% oxygen and 97% nitrogen) for 24 h reduced chilling-injury symptoms in 'Fuerte' avocado fruit after 3 weeks of storage at 2ºC. Also softening was slowed down by this treatment. However, this treatment is not yet employed commercially.

Acetaldehyde vapor (5000 $\mu l.l^{-1}$ for 18 h) pretreatment of 'Fuerte' avocado fruit was reported at this meeting, but is not yet being used commercially.

In our laboratory, methyl jasmonate pretreatment reduced chilling injuries in 'Fuerte' avocado fruit, but there is still much to learn before it can be applied.

Hydrocooling was tested as a result of cooling the fruit as rapidly as possible to the optimal storage temperature, but after 25 min on the packing line the net gain, in cooling, was found to be inefficient for the method to be economical.

Calcium infiltration has been known for many years to slow down softening in avocado, but it is not being used commercially.

Carbon dioxide shock pretreatment (25% in air, for 3 days) was found-to be a promising treatment in South Africa (Bower-et al., 1989) and also in Israel to chilling injury development.

In a recent publication (Prusky et al., 1995) and at this congress, it was suggested that a Postharvest dip or spray of avocado fruit with the antioxidant butylated hydroxyanisol (BHA) might reduce Postharvest decay in avocado by modulating the natural fruit resistance. This treatment has reached the semicommercial experiment stage, but is not being used yet.

3.2 Storage conditions

Temperature is no doubt the single most influential factor in fruit storage. All biological processes are controlled by temperature and thus fruit quality and ripening are strongly affected by storage temperature. However, it should be remembered that we cannot “cure” bad quality fruit with Postharvest treatments. The issue is to slow down the natural deterioration by lowering the temperature of the fruit as much as possible without damaging it. Avocado, being of subtropical origin, should not be cooled to even close to its freezing point, as it suffers chilling injury at temperatures much above the freezing point. All this makes the art of maintaining the quality of avocado fruit, during and after cold storage a difficult task. To demonstrate this in quite a simple way, we present data which were generated last year during cold storage of ‘Ettinger’ fruit, harvested at the end of October – which is about mid-season for harvesting this variety in Israel. Fruits were stored at 2, 5, and 22°C, those from 2 and 5°C were transferred after 3 weeks to 20°C for ripening. Fruit samples were taken weekly for determination of firmness using a Chatillon pressure tester. We know from experience that we can feel manually any change in firmness, only when less than 40 N is needed to penetrate the fruit; and the fruit is ready to eat when less than 15 N is needed for penetration. As shown in Figure 1, at 5°C the fruit became softer already after 2 weeks of storage, while the fruit stored at 2°C remained firm for 6 weeks. However, after 3 weeks at 2°C we started to observe chilling-injury symptoms, while none developed at 5°C. From the same fruits on which firmness was determined, peel discs were prepared (10 mm in diameter and ~2 mm thick). Then their ACC-oxidase activity was assayed by measuring ethylene production after incubation with or without the addition of a saturating concentration of ACC. The avocado peel has a surplus of ACC-oxidase activity on the day of harvest (Fig. 2), which decreases during storage. At a chilling-inducing temperature of 2°C, the removal of fruit to shelf-life conditions (20°C), for ripening, significantly enhanced ACC-oxidase activity after 3 and 6 weeks at storage whereas at 5°C this activity was hardly noticeable. Similar patterns were found in our studies with fruit of the 'Fuerte' and 'Reed' varieties. It appears that, as in apples (Lelievre et al., 1995) enhanced ACC-oxidase activity in avocado is related to chilling injury development.

Chilling symptoms in avocado may appear in different ways: surface or internal browning, surface pitting, failure to ripen, increased susceptibility to microorganism attack, and pulp spots are found in South Africa (but generally not in other places) as well as chlorotic appearance of the peel, as is found with cold- stored Israeli 'Ettinger'. Most of the pretreatments mentioned above are supposed to maintain quality by enabling fruit storage at low temperatures which would otherwise - without the pretreatment - cause chilling injury.

3.3. Atmosphere composition

All methods and combinations of atmosphere modification which work with apples were tried also with avocado, but so far they have not succeeded as well as with apples and there is no large-scale commercial use of these methods with avocado. There is a lot to study on the local level, in each growing region, before controlled atmosphere (CA) and modified atmosphere (MA) can be used commercially on a large scale.

We all know that ethylene is involved in avocado ripening and thus when we are interested in delaying ripening during cold storage, we have to eliminate the ethylene in the storage atmosphere. This is important for normal atmosphere storage as well as for CA and MA. The presence of ethylene during cold storage would cause pulp discoloration and shortening of shelf-life after removal from cold storage. Ethylene can be removed by ventilation, absorption by potassium permanganate, or by scrubbers or other technologies in CA storage. However, ethylene can help us to obtain a better quality fruit for the consumer when it is used as a ripening agent. This has been done in Israel for more than 25 years, mostly for big customers who insist on having all the fruit ready for consumption on a certain day. We introduced this idea to some of our customers in Europe already in the 1970s in order to develop the "ready to eat" line of avocado in some of the chain stores. In addition to achieving uniform and controlled softening, the fruit might escape rots, as the accelerated ripening leaves less time for pathogenic fungi to develop and the final result is a better quality fruit for the consumer.

4. Concluding remarks

It should not be forgotten that all the common knowledge of today is based on a lot of research work which has been done in the past. The bulk of the research on enzymes in avocado fruit was done mainly with regard to fruit ripening and quality. We use various enzymatic assays as markers in many of our studies. The basic role of cellulase and pectic enzymes in avocado softening has been studied all the way to the gene level. In a presentation from Japan at this congress, the purification of and role for β-galactosidase in avocado softening were discussed. There is still a lot to learn about the ripening and quality of avocado fruit, and their control.

Postharvest treatments of the fruit have an important effect on its quality, but we should bear in mind that every fruit, even under the best storage conditions, has a limit beyond which its storeability with good quality cannot be stretched. The limit is a genetic one and therefore the only way, in the future, to extend this limit significantly is to create better genetic combinations. This might be achieved by either classical breeding or by molecular biology methods and genetic engineering. The role of fruit physiologists is to continue to study the processes determining quality in order to advise the geneticists about the important traits and the related enzymes which could be manipulated. Then, when the new varieties bear fruit, to help the geneticists to evaluate the results of their work by running storage simulation tests and analyzing the physiological characteristics of the new varieties. There is much work ahead of us.

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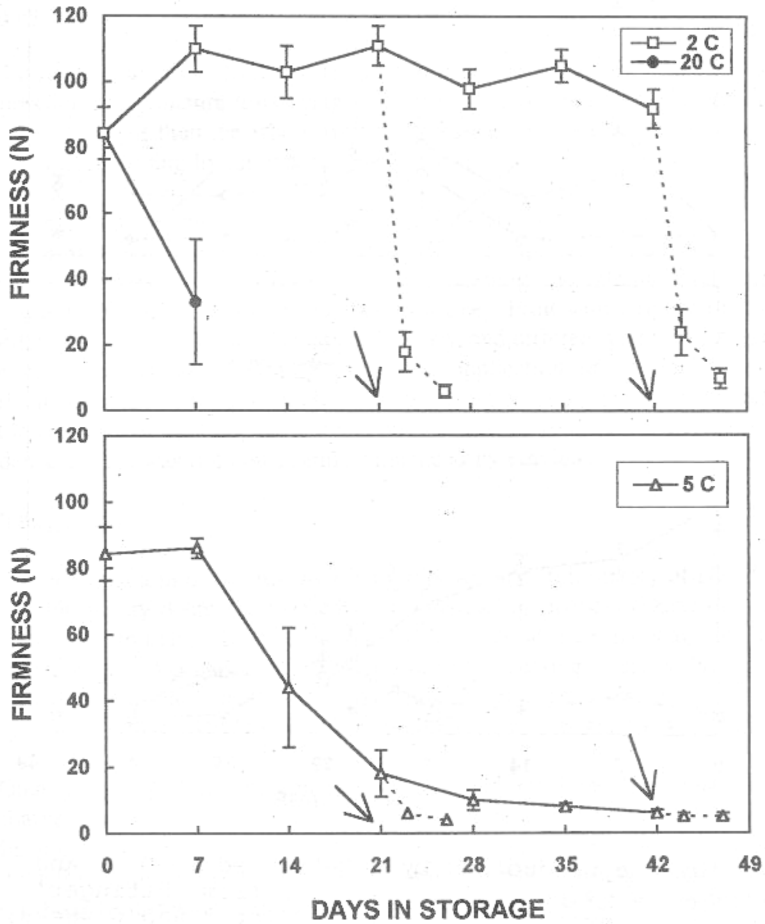

Fig. 1. Changes in firmness of 'Ettinger' avocado fruits during storage at 2, 5 and 20°C for 3 and 6 weeks, followed by shelf-life conditions. Vertical bars represent the ±SD of ten Chatillon penetrometer readings. Arrows indicate time of transfer to shelf-life conditions. Broken lines represent observations carried out under shelf-life conditions (20°C).

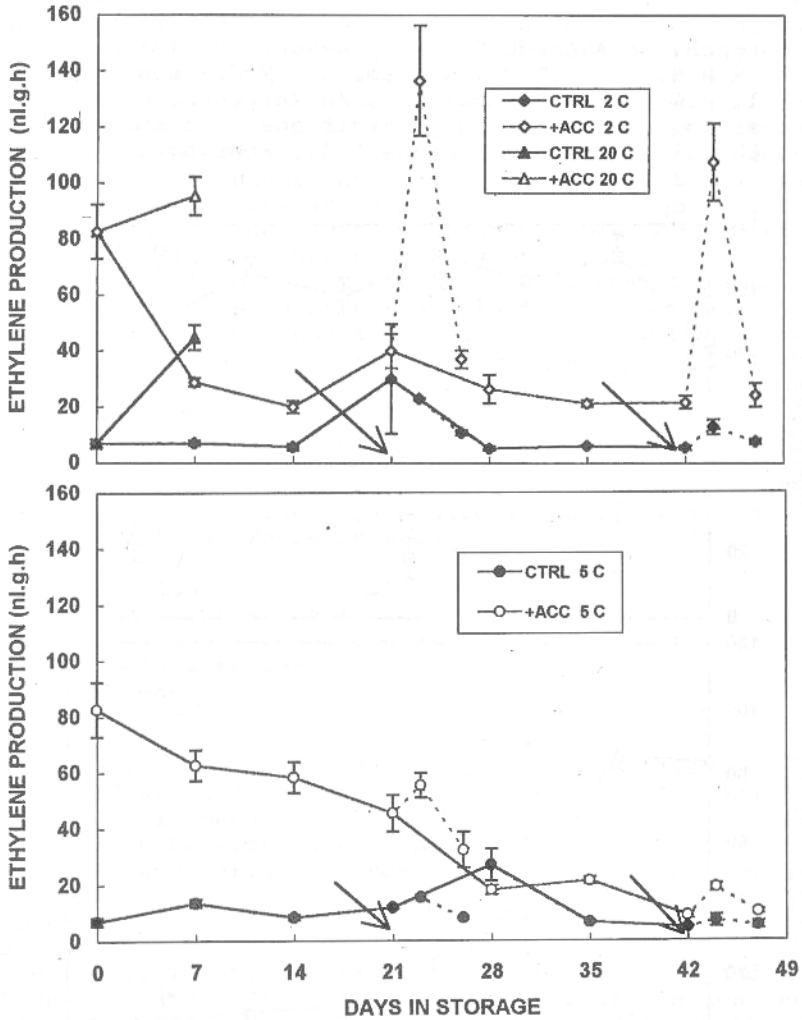

Fig. 2. Ethylene production by ACC-treated Δ– O –◊ and nontreated ▲ – ● – ♦ peel discs prepared from 'Ettinger' avocado fruit stored at 2, 5 and 20 C for 3 and 6 weeks, followed by shelf-life conditions. Vertical bars represent the ±SD of five replications. Arrows indicate time of transfer to shelf-life conditions. Broken lines represent the rate of ethylene production under shelf-life conditions (20°C).