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Establishing appropriate maturity and fruit mineral content norms for the main avocado export cultivars

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ABSTRACT

During the late nineties, a study was initiated aimed at solving the acute quality problems encountered with the Pinkerton cultivar. Since then, localised, acute quality problems have occurred from time to time with other cultivars. SAAGA has therefore sanctioned the extension of the Pinkerton project so as to include all export cultivars. The aims of the study were to identify the major risk factors affecting post-harvest quality disorders, such as grey pulp and to develop appropriate fruit maturity and mineral content norms.

The following aspects were identified as major risk factors (terms in brackets represent, in that order, less and more risky circumstances): maturity (less vs more mature), maturation rate (slower vs faster maturation), soil type (lower vs higher potential), nitrogen fertiliser practices (less and inorganic vs more and organic), orchard temperatures (cooler vs warmer), rainfall (lower vs higher), tree age (older vs younger), tree load (higher vs lower), fruit size (smaller vs bigger), storage temperature (higher vs lower), storage condition (CA/SmartFresh vs RA), storage period (shorter vs longer).

During 2003 an effort was made to establish appropriate maturity cut-off points for cultivars other than Pinkerton. This was done with fruit from the Kiepersol area. The cut-off points cited hereunder represent fruit from a problematic area during a dry season with an intermediate fruit load. Under these conditions the cut-off points (in terms of fruit moisture content) are respectively: Hass between 71% and 69%; Fuerte between 75% and 73%; Pinkerton between 76% and 74%; Edranol around 73% and Ryan around 72%. The proposed upper cut-off points (high risk orchard + high risk season) and lower cut-off points (low risk orchard + low risk season) are as follows: Hass 73% and 65%; Fuerte 76% and 68%; Pinkerton 77% and 70%; Edranol 76% and 71%; Ryan 73% and 65%. These values are, however, subject to further refinement and updating.

In terms of the fruit nitrogen content recommendations, we propose that in a problematic area such as Kiepersol, the specifications developed for Pinkerton (not higher than 1.7% during December; lower than 1% during February and, importantly, no intermittent peaks) be used for Fuerte and Edranol. These values also apply to Hass and Ryan, but one month's leeway is acceptable. Fairly similar norms apply for the Tzaneen region. Although Levubu is earlier, it is not necessary to advance the cut-off points, as the fruit seem to remain relatively small and be less prone to physiological disorders. In terms of the KwaZulu-Natal area, the above cut-off points may shift between one and a half and two months later, depending on the latitude.

In so far as the other measured elements (P, K, Ca, Mg, Zn, Cu, Mn, Fe and B) are concerned, a number of weak but interesting trends were observed. The most important of these concerns a relationship between pulp Fe content and black cold incidence. Spray trials with this element are therefore proposed. However, our general recommendation regarding the elements other than nitrogen is to ensure that an orchard complies with present soil and leaf norms for the specific element. This recommendation will be updated after focused experiments (e.g. applying Fe sprays and then assessing the effect on black cold) have been conducted.

During 2003 a range of trials were conducted in the Kiepersol area where the effectiveness of the ethylene inhibitor, SmartFresh®, was evaluated under commercial conditions. The results showed

both SmartFresh® and CA to widen the grey pulp dependent maturity window by approximately 3% in smaller fruit. In bigger fruit, the leeway afforded by SmartFresh® and CA was more difficult to determine due to variation between samples. It will nevertheless be safe to assume that the use of CA or SmartFresh® will allow the maturity cut-off points to be lowered by at least 1% in bigger fruit.

This project proved to have major extension value. Considerable personal interaction took place between growers and researchers. Major improvements in the quality of fruit from certain producers were noticed during the last number of seasons. However, South African avocado exporters have been blessed (in terms of fruit quality) with two very dry seasons. The rainy years are, however, to return with major quality implications, especially when coinciding with an off-season. The long storage period required for South African avocados remains a challenge, and competition with other countries is also to become fiercer. Quality is therefore to become even more important in terms of market flexibility, volume control and pricing.

INTRODUCTION

Considerable post-harvest physiological problems were encountered with the Pinkerton cultivar during the late 1990's. This prompted the South African Avocado Growers' Association (SAAGA) to initiate a project aimed at establishing the causative factors of post-harvest quality disorders such as grey pulp and to develop appropriate control strategies. The recommendations stemming from this research primarily concerned two focus areas, namely, maturity control and nitrogen management (Kruger *et al*., 2000, Kruger *et al*., 2001, Snijder *et al*., 2002).

The effect that the recommendations had on the overall quality of export 'Pinkerton', was such that SAAGA decided to extend the project so as to include the other export cultivars (Snijder *et al*., 2003). This was especially important, since the industry encountered similar problems to those experienced in 'Pinkerton', with the other cultivars (including 'Hass') towards the end of the last wet cycle, around the turn of the century.

The primary aims of this report are to notify producers of the most important risk factors, to develop maturity cut-off points for the other commercial cultivars and to establish fruit pulp nitrogen content norms.

RISK FACTORS

In so far as grey pulp is concerned, maturity has been shown to be the main causative factor. More mature fruit are more prone to develop grey pulp than less mature fruit. Cultivar-specific maturity cut-off points are therefore pertinent. In addition, the rate at which the fruit matures is also important. In a previous study we recommended that, in 'Pinkerton', the rate of moisture loss should not exceed 1% during any given 10-day period. This observation was confirmed in this study. When two 'Pinkerton' orchards from the same producer were compared, we found fruit that lost 7% in moisture during a 70-day period developed grey pulp at a mean moisture content level of between 74% and 75%. In contrast fruit that lost 16% moisture over the same period developed grey pulp earlier at a maturity of around 76% to 77%.

The next risk factor concerns nitrogen fertiliser applied and the subsequent leaf and fruit pulp nitrogen content. For instance, in the above case, the pulp nitrogen content of the fruit from the better orchard was around 1.6% during January and this reduced to 1.45% during February and 1.2% by March. In contrast, the poor-storing fruit was around 1.5% in January, but instead of decreasing, the pulp nitrogen content increased to 1.56% during February whereafter it decreased to 1.3% by March.

Other environmental factors identified to play a role were soil type, orchard temperature and rainfall. In general, trees planted on very high potential soils produced fruit with poor storage potential, especially if these orchards were located in warm production areas. This situation was further exacerbated during a wet season, especially when the crop load was low. High rainfall during an off-season was found to be particularly detrimental to storage potential. In addition to these factors, tree age was also found to play a role in 'Pinkerton'. Younger trees generally produced fruit with poorer storage potential than older trees. However, this effect seemed to be less prominent in other cultivars, especially 'Hass'.

Post-harvest factors shown to play a role in the expression of grey pulp were fruit size, storage temperature, storage atmosphere and storage period. These will be dealt with in a separate section.

MOISTURE CONTENT

Determining grey pulp threshold values during the 2003 season

With reference to the research previously conducted on 'Pinkerton', different cut-off points were formulated for high risk and low risk production areas. In addition, seasonal effects were also taken into account. This culminated in four cut-off points according to area and season, namely, high risk area plus high risk season, high risk area plus low risk season, low risk area plus high risk season and low risk area plus low risk season. These factors were taken into account when developing cut-off points for the other cultivars. The 2003 research was conducted in the Kiepersol area, which is a high risk region.

Hass

Being the most important cultivar, considerable effort went into the establishment of appropriate maturity cut-off points for Hass. The samples of 'Hass' fruit used for maturity and mineral content analyses were obtained from 23 orchards located on 9 farms. Fruit from eleven of these orchards were harvested and stored, on average, six times from April to July. The fruit were stored at 3°C in an attempt to also induce black cold injury. This unfortunately confounded the results somewhat in that a type of internal chilling injury, with similar symptoms to grey pulp, developed in the beginning of the harvest window. This symptom nevertheless abated during the middle of the season, enabling the recording of classical grey pulp symptoms towards the end of the season. In most cases, grey pulp started to become a problem when the 69% moisture mark was reached. Fruit between 69% and 72% tended to be clear of grey pulp, indicating that an appropriate maturity cut-off point lies between 69% and 72% in the high risk Kiepersol area during a low risk dry season.

Fuerte

Unfortunately, the internal chilling injury symptoms described above, influenced 'Fuerte' to a greater extent than it did 'Hass'. No intermittent grey pulp free period was observed. It was therefore decided to use dusky cold, an external manifestation of grey pulp, which shows a very similar incidence pattern to grey pulp, as a benchmark. As was the case with grey pulp in Hass, dusky cold was noticed at a low intensity during the beginning of the season when the fruit was around the 80% moisture content mark. It then disappeared, only reappearing when the moisture content reached 75% – 73% (depending on the orchard). It remained a major problem as the fruit moisture content further decreased. The 75% – 73% cut-off point is very similar to that determined for 'Pinkerton' produced in the Kiepersol area during a low risk season.

Edranol

Interesting observations were made regarding the maturation rate of 'Edranol'. During 2003, the maturation rate of 'Edranol' was found to be slower than that of 'Fuerte' and 'Pinkerton' and possibly even 'Ryan'. Grey pulp only started to develop during the first week of July, at which stage the moisture content was around 73%.

Ryan

The incidence of grey pulp was relatively low in 'Ryan'. The first symptoms started to appear around the 72% moisture content mark but the incidence was rather erratic.

Pinkerton

The present study confirmed that the maturity cut-off points previously formulated for 'Pinkerton' are correct.

Recommended cut-off points

As mentioned above, we now have experimentally determined cut-off points for all cultivars grown in high risk area during a low risk season. We still require cut-off points for high risk areas during a high risk season and for low risk areas during both low and high risk seasons. However, it is possible to make estimations for these cultivars based on our experience with the 'Pinkerton' cultivar. Needless to say, the recommendations made hereunder are conservative as a "rather safe than sorry" approach is followed.

Reference is hereunder made to high risk and low risk areas. A typical high risk area is the Kiepersol area, especially the orchards located at lower altitudes on old banana lands. A number of high risk foci were also identified in the Tzaneen area where warmer microclimates exist. However, high risk farms were also found at higher altitudes where excess organic nitrogen was applied in the past. This is, however, not a permanent situation and it can be rectified over time.

Low risk areas are typically the higher altitude farms and orchards planted in sandy soils of the White River, Nelspruit and Barberton areas. Most KwaZulu-Natal farms also fall within this category. An interesting observation was made in the Levubu area. Although the area can be classified as warm and the soils are high potential, we found fruit growth to level off quite early, resulting in smaller fruit with reasonably good storage potential.

Hass

It is recommended that producers stop harvesting 'Hass' at 73% in a high risk area during a high risk season. During a low risk season the cut-off point can be lowered to 71% for the more problematic farms within the high risk area. Better farms in such areas may lower this point by a further 1% – 2% during low risk years. In high-altitude low risk areas, we recommend that producers stop harvesting at 70% during high risk off-years with high rainfall. During drier years, this may be stretched to as low as 65%, especially during an on-year.

Fuerte

In high risk areas, it is recommended that producers stop harvesting at a moisture content as high as 75% during a high risk season. During lower risk seasons this may be reduced to 73% for the most problematic farms and 72% for better farms. In lower risk areas, the maturity may be stretched as far as 68% in low risk seasons, but producers should probably stop harvesting at 70% during a high risk season.

Edranol

As mentioned above, we found 'Edranol' to mature at a slower rate than 'Pinkerton' and 'Fuerte' and it is possible that, in future, properly fertilised orchards may be harvested at a lower maturity. In the meantime, we recommend a cut-off point around 75% for high risk conditions and around 72% for low risk conditions.

Ryan

The physiological stability of 'Ryan' is well known and this cultivar can be left to reach a maturity of 65% on low risk farms. However, we recommend that high risk producers harvest their fruit before the 70% level is reached.

Pinkerton

Our previous recommendations for this cultivar are still valid. It is important that farmers in high risk areas harvest their fruit at a moisture level as high as 77% in a high risk season. This may be lowered to 74% during a low risk season. In a lower risk area it is recommended that producers stop harvesting at around 73% during a high risk season and at 70% in a low risk season.

Effect of post-harvest treatments

The storage trials referred to above were conducted under regular atmosphere (RA). During the early stages of the 'Pinkerton' research project, we found controlled atmosphere (CA) to have a negligible effect on grey pulp. However, the fruit we worked with during those early stages of the project were extremely over-mature and we have since found CA to reduce the incidence and intensity of grey pulp if applied to fruit that are within the recommended maturity range.

During 2003 a range of trials were conducted in the Kiepersol area during which the effectiveness of the ethylene inhibitor, SmartFresh®, was evaluated under commercial conditions. This was done after the product was successfully commercialised in the Tzaneen area (Lemmer *et al*., 2002, Lemmer *et al*., 2003). The results showed both SmartFresh® and CA to widen the grey pulp dependent maturity window by approximately 3% in smaller fruit. In bigger fruit, the leeway afforded by Smartfresh® and CA was more difficult to determine due to variation between samples. It would nevertheless be safe to assume that the use of CA or Smartfresh® will allow the above listed maturity cut off points to be lowered by at least 1% in bigger fruit.

During one of the experiments RA, CA and Smartfresh® treated fruit were stored for up to 60 days and evaluated at 10 day intervals during the storage period. Grey pulp was found to increase linearly as the storage period lengthened. The results clearly demonstrated the positive effect that, especially, Smartfresh® has on the control of grey pulp during prolonged storage. This might give exporters more flexibility in their marketing program. However, it should always be remembered that fungal infections become a major problem when storing avocados for extended periods.

Importance of correct maturity measurement techniques

The use of moisture content analyses has become standard practice in the South African avocado export industry during recent years. Industry members are, however, discouraged by the effort involved. The ARC-ITSC was therefore requested to look into alternative maturity measurement techniques. An alternative procedure evaluated during the last season involved the use of fruit density as an indicator of the moisture : oil ratio of the fruit. Various ratios of the length, width, volume and mass were considered, all of which proved to be unsuccessful. We have since joined forces with a biotechnology company in an attempt to develop a genetic probe for more convenient maturity testing.

A number of options may be considered to simplify the current moisture measurement process. It is suggested that avocado growers make use of automated moisture content balances similar to those used by the macadamia industry. The advantage of this equipment is that the balance simultaneously dries the sample and automatically measures moisture loss. The disadvantage is that the apparatus can only measure one sample at a time. This brings us to the importance of appropriate sampling. If the sample size is too small, moisture content analysis is not representative of the orchard. We recommend that 20 randomly harvested big fruit (count 10 – 12) and 20 smaller fruit (count 16 – 18) be separately pooled per orchard. The sample must contain equal quantities of pulp from each fruit and it must be thoroughly mixed before taking a sub-sample for moisture content analysis. Moisture content analysis must be conducted on a bi-weekly basis during the beginning of the season but this must be shortened to a weekly basis during the harvest window period.

MINERAL ANALYSES

Grey pulp and fruit pulp nitrogen content

One of the aspects addressed in the previously mentioned 'Pinkerton' research project involved the use of fruit pulp mineral content as an indicator of storage potential. This involved the formulation of guidelines for specific times of the season. One of the recommendations made is that the nitrogen content of the pulp should not exceed 1.7% during December and that this value should decline to less than 1% by the end of January, where it should remain until harvest. A pulp nitrogen level exceeding 2% in December was found to be detrimental to fruit quality, especially if the level declined at a slow rate until harvest. However, if the fruit pulp nitrogen content was at the correct level by December (1.7%) but it increased or declined at a too slow a rate, there may also be a negative impact on fruit quality. An intermittent peak after reaching the 1% level was also shown to be detrimental to fruit quality.

In general, the fruit pulp nitrogen recommendations formulated for 'Pinkerton' have been shown to apply to the other cultivars as well. The timing of the threshold values (1.7% in December and 1% in January) will differ according to the cultivar and growing region. For instance, by using the known maturation rates of different cultivars, it may be recommended that the pulp nitrogen content of Fuerte produced in the Levubu area should be under 1% by the last week of December. At the other end of the spectrum, Hass produced in Southern KZN must be under 1% by the end of March. However, we would not like to be too over-prescriptive regarding this issue. It is rather suggested that exporters notify SAAGA of problem cases in terms of storage potential and that researchers visit the specific orchards and draw samples on a regular basis for mineral analysis. Recommendations can then be made to the producer and the problem rectified during subsequent seasons.

In so far as the relationship between grey pulp and the pulp content of the other elements (P, K, Ca, Mg, Zn, Cu, Mn, Fe and B) are concerned, we remain with our previous recommendation that it is best is to ensure that an orchard complies with present soil and leaf norms for the specific element.

Black cold injury and fruit pulp iron content

The relationship between excessive nitrogen fertilising and grey pulp has now been firmly established. However, in the case of black cold injury, an association between the disorder and mineral excesses / deficiencies has not been established as yet. It was thus interesting to find a negative correlation between black cold injury and pulp Fe content in both Hass and Fuerte during the present study. It may therefore be worthwhile to conduct Fe sprays during the coming season so as to establish whether this will reduce the incidence and intensity of black cold injury.

CONCLUDING REMARKS

It is anticipated that the guidelines presently being developed will contribute towards containing the quality problems periodically encountered with all South African export cultivars. It is important that producers with persistent quality problems be continually assisted with a research based extension service. Researchers must partake in this extension service and it should include both maturity and mineral content analyses. Newly developed Southern Hemisphere production regions are increasingly competing for the South African market share. Under these circumstances, persistent good quality is to become an ever more important marketing tool.

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