Review of 30 years postharvest research

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ABSTRACT

The Technical Committee of the South African Avocado Growers' Association (SAAGA) was constituted in 1977, with Prof JM Kotzé coordinating the research done at the University of Pretoria, University of Natal, Randse Afrikaans Universiteit (RAU) and private groups, including HL Hall & Sons, Westfalia and Letaba Ko-op. One of the main contributions by the SAAGA Technical Committee was the annual publication of the SAAGA Yearbook, a valuable means of communication between producers, researches and other parties. In this paper the progress through almost four decades on post-harvest research will be reviewed.

In the early 1980s most producers were more concerned with root rot, while post-harvest diseases were ignored. With the establishment of the Committee, a change in this attitude occurred, where the significance of postharvest diseases and physiology investigations were acknowledged. Under the leadership of Prof Kotzé and Jan Toerien, *Phytophthora* and postharvest diseases were eventually successfully controlled. The second huge opportunity was the poor state of export arrivals on the overseas market. An age-temperature-maturity system was developed into the state of present exports.

Between these two main spheres of postharvest research, various studies were published on techniques, methodology, soil and climatic factors, and physiological/biochemical topics. Some papers presented robust data with sound scientific methodology and conclusions, while others were of speculative and questionable value. In this review these topics are discussed and a synthesis of the present knowledge on avocado post-harvest presented.

INTRODUCTION

Since the planting of the first small avocado orchards in South Africa during the 1930s by Dr Merensky at Westfalia and Lanion Hall at HL Hall & Sons, the avocado industry made huge progress. The main advances were:

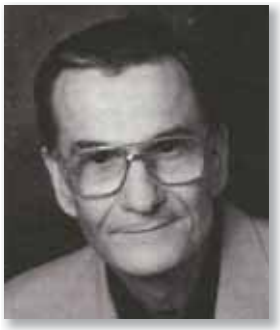
1. The establishment of the Research Committee.
2. Survey of the export markets.
3. Oil determination, disease control and packaging modification.
4. Switch to road transport.
5. Application of the model for temperature management. Reefer containers replace porthole containers.
6. PPECB and shipping lines accept shipping temperature recommendations.
7. Export coordination.
8. Implementation of ripe and ready and the establishment of avocado processing.
9. Application of the Densimeter and MCP (Smartfresh™).
10. Ultra-low temperature storage.

The early years prior to 1970

The industry expanded rapidly in the 1960s due to the greening disease which caused havoc in citrus. SAAGA was constituted in 1967 when a forum was recognised for the communication between producers and other interested parties. The Technical Committee of SAAGA was constituted in 1977, with Prof JM Kotzé coordinating research done at that stage at the University of Pretoria, University of Natal, Randse Afrikaans Universiteit (RAU) and private groups, including HL Hall & Sons, Westfalia and Letaba Ko-op. One of the main contributions by the SAAGA Technical Committee was the annual publication of the SAAGA Yearbook. For a while producers made handsome profits, however 10 years later, after the establishment of SAAGA, the industry faced a crisis. *Phytophthora* was rampant without any control measures; black spot caused huge losses, postharvest diseases were common, the causes unknown and with no control, while cartons collapsed and rail trucks with avocados disappeared from the scene to be discovered months later on some obscure rail siding.

The industry acknowledged the need for a coordinated research effort and in effect, the Research Committee was founded by Jan Toerien, Ronnie Lunt, Clive Mitchell and Willie Pretorius.

The photo of this 15 ton insulated rail truck dates back to the 1930s. These trucks were used to dispatch avocados to Johannesburg and Cape Town. Although "Refrigerator" appears on the truck, it did not have its own cooling unit. Dry ice was placed in the truck, after which cartons were loaded – not on pallets, but instead a human chain was formed and cartons passed on out of the pack house, from one person to the next into the truck. The window on the top of the truck was used to measure temperature and when out of range, more dry ice was dumped into the truck.


Prof JM Kotzé


Jan Toerien


Joe Darvas

1975 – 1985

Subsequently Jan Toerien employed a young man from Hungary as Pathologist at Westfalia in 1978. Within one year Joe Darvas successfully controlled *Phytophthora* with Metalaxyl (Table 1), while under the guidance of Prof Kotzé, he identified most of the postharvest pathogens and controlled black spot *(Pseudocercospora purpurea*) with two copper sprays – one in mid-November and the next spray in mid-January. Joe Darvas will mainly be remembered for Fosetyl-Al. Within three years of successful control with Metalaxyl, the fungus developed resistance against fungicide. Although Fosetyl-Al initially performed poor towards *Phytophthora* in one year, trees improved significantly in the second year and in the fourth year completely recovered from the fungus. The improvement in tree condition had a huge influence on postharvest fruit condition. With the increased yield and canopy cover, the stem-end rot fungi complex became more prevalent while nutrient ratios in the fruit changed, influencing postharvest diseases and fruit disorders.

From 1980 to 1981 a couple of new developments and a greater understanding of the postharvest handling of avocados emerged:

Table 1. Avocado tree after one year treatment (Darvas, Kotzé & Toerien, 1979).

	Tree health (Excellent - 0, Dead - 10)
Metalaxyl	0.9
Fosetyl-Al	2.8
Ethazole	4.6
Control	4.8

1. It was recognised that fruit postharvest quality is depended on the storage period – the longer the fruit was stored, the worse the fruit condition.
2. The beneficial effects of calcium on root rot control and fruit quality was established.
3. Ronnie Lunt showed that the cooling rates vary with the position of the fruit on the pallet (Lunt & Smith, 1981).
4. Avocado fruit were artificially ripened with ethylene gas.
5. And finally, Blackie Swart constructed an instrument whereby fruit firmness could be quantified (Swart, 1981).

In 1981, Eileen Kushke surveyed avocados from South Africa and from other countries (Bezuidenhout & Kuschke, 1982). The results were shocking (Table 2). Jan Toerien wrote in his memoirs: "Our (Westfalia) trees were the best and we expected the same from our fruit. From the survey we had the worst fruit in the industry and this forced us to take drastic steps."

The firmometer. The base of the avocado is positioned according to the bottom of the plunger; a weight is attached to the area where the plunger presses onto the skin without penetrating the fruit. The firmness is read from micrometer.

Table 2. The average industry incidences of postharvest diseases and disorders in South African avocados found at Rungis, France, during a survey done from March to June, 1981 (Bezuidenhout & Kuschke, 1982).

Parameter	Average
Firmness on arrival (Scale 0-15 Hard, 16-25 Breaking, More than 25 Soft)	38
% Black cold damage on arrival	5
% Anthracnose when ripe	9
% Stem-end rot when ripe	16
% Pulpspot when ripe	16
% Grey pulp when ripe	21
% Vascular browning when ripe	40
Transit time from packed to arrival at market	29 days

With the analysis of Eileen Kuschke's 1982 results, the 5.5°C temperature regime, which was rigorously applied by the industry, was seriously questioned (Bezuidenhout & Kuschke, 1983).

1982 saw the experimental use of controlled atmosphere, which in a couple of years was commercially implemented.

In 1983, Athur Rowell published an article on the control of anthracnose and stem-end rot by prochloraz, which is still used today (Rowell, 1983).

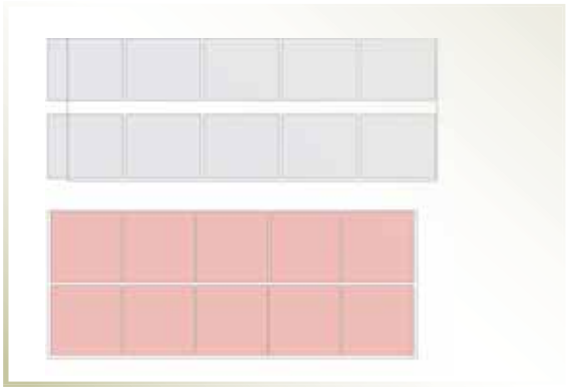


Figure 1. Top – ISO pallets in a container. Bottom – avocado pallets developed by Jan Toerien in the same container.

Jan Toerien saved huge amounts of money between 1984 and 1986 by modifying the pallet and carton dimensions for 100% utilisation of the container (Fig. 1). The standard ISO pallet is 1 x 1.2 m and only 2000 cartons filled the container. With the new design, 2520 cartons fitted into the container. The saving for 1984 was R14 million/annum (Toerien, 1997).

Other significant advances during 1975-1985 were:

1. Oil as an index of maturity was published (Holzapfel & Kuschke, 1977).
2. Joe Darvas refined the well-known Z-equation for black spot (Darvas, 1982).
3. During that period, Fosetyl-Al replaced Metalaxyl (Darvas JM, Toerien JC & Milne DL, 1984).

1986 – 1995

In 1987, South Africans were privileged to host the first Avocado World Congress, mainly due to the huge efforts by Jan Toerien and his secretary, Ray van Zyl.

During the congress, Louis Vorster presented a paper on the storage temperature regimes for avocados (Vorster, Toerien & Bezuidenhout, 1987). The main conclusions were:

1. Temperature should decline during transit.
2. The more mature the fruit, the lower the temperature.
3. The temperature depend on the cultivar.

This model did not go well with the bureaucrats at PPECB. From then on for six years, symposia like this one were characterised by a verbal battle

between PPECB and the industry regarding temperature management. Eventually, Jan Toerien and Dave Schreuder (CEO, PPECB) delegated Gawie Eksteen (PPECB) and the author to resolve the differences. Subsequently, a paper was presented by Bezuidenhout & Eksteen (1994) outlining time-temperature principles applied to date.

The author at reception where he and Dr Gawie Eksteen received SAAGA's Avocado Golden award.

The Australian model on tree phenology was introduced to the South African industry by Nigel Wolstenholm (Whiley & Wolstenholm, 1990) (Fig. 2). Many farmers today use this model for their orchard practices where especially the management of nitrogen fertiliser bear an influence on fruit physiology.

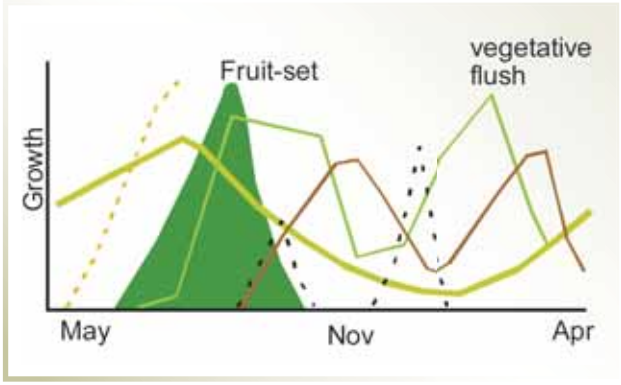


Figure 2. The tree phenological model by Whiley & Wolstenholm.

1996 – 2005

During 1991 and 1997, porthole containers (Fig. 3) were replaced with refrigerated containers, or Reefer containers.

Ripe & Ready fruit started off slowly – first with OK Bazaars, then Woolworths, Spar and Shoprite/Checkers (Bezuidenhout, Unpublished).

Today, with oil and guacamole it contributes to the financial viability of avocados. Each of these products has its own post-harvest or food science challenges.

Stefan Köhne introduced the densimeter from Europe to South Africans (Köhne JS, Kremer-Köhne S & Gay SH, 1998).

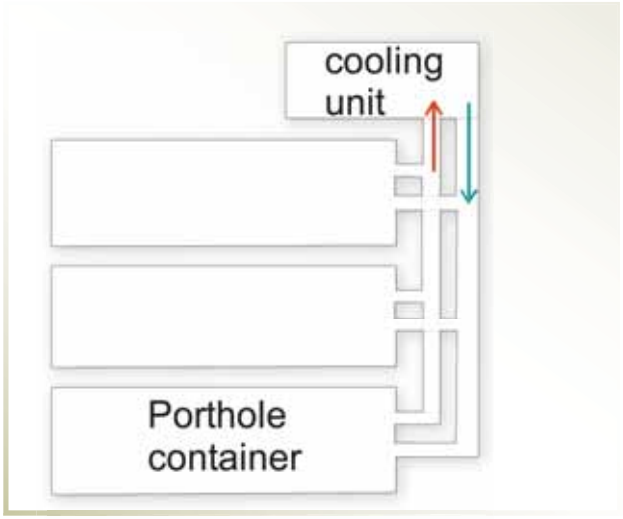


Figure 3. A stack of porthole containers in the hull of a ship.

The convenient densimeter, used to measure firmness, provides mutual understanding for the supplier and the receiver to understand Ripe & Ready fruit-firmness.

From the late 1990s, controlled atmosphere (CA) arrived on the scene. Although a wonderful "Aspirin" (a term first used by Malcolm Dodd in this context) to the shortcomings of Reefer containers, costs increased heavily. Lemmer *et al*. (2003) proved MCP (1-methyl cyclopropene) is a viable alternative to CA in semi-commercial trials at Westfalia. The full-scale commercial application started in 2003 with Smartfresh™ whereby the CA cost stabilised for obvious reasons.

The latest advancement is ultra-low temperature management which promises to implement phytosanitary requirements for exports (Van Rooyen & Bezuidenhout, 2010).

CHALLENGES

Plenty of opportunities remain to conduct fruitful research to improve the South African avocado post-harvest condition.

Uneven ripening (including MCP-treated fruit and poor colour development with 'Hass') should be addressed in earnest. Feedback from the ripeners' complaints indicate the South African research efforts to date failed to address the problem. SAAGA's Research

Committee should scrutinise research project proposals relating to this topic vigorously and evaluate it on a regular basis – *not* once annually. Huge investments were made in these projects with no returns. Developing protocols for the ripeners without their full backing and commitment is a futile exercise.

In-line maturity measurement, although claimed to be successful, has not yet been applied in the industry. In the author's view other larger fruit industries should be monitored for success with in-line maturity measurement before we embark on new research projects.

According to Richard Nelson, the incidence of grey pulp is unacceptable. The causes are well known for 'Fuerte' and 'Hass' i.e. too mature, fruit age and high nitrogen levels. Exporters should consider financial gains while harming the reputation of the South African industry by sending high risk fruit.

Prochloraz and H_3PO_3 based products should be used judiciously. The industry does have only these fungicides for the control of *Colletotrichium* and *Phytophthora*. In the case of resistance, the industry faces a grim feature while a ban on the export market will have a similar result. The author suggests that an established and reliable institution with means for analysing these compounds should be identified. The South African parastatals used in the past for analysis are underperforming and are at present incapable.

The new trend in the use of shade nets are going to manifest in an interesting scenario. The microclimate differs significantly from an open orchard. In due time the insect and microbial ecosystem under shade netting will differ from standard cultivation (Beer, 1987). The net results may be new diseases and defects, offering unique research opportunities.

Finally, researchers must be wary not to re-invent the wheel. Recently a number of articles were published on break in the cold chain; even a project proposal was made on the subject this year. Gawie Eksteen and his colleagues have done the work and defined the protocol (Eksteen, 1995).

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