South African Avocado Growers' Association Yearbook 1995. 18:67-73

A Preliminary Study on Variation in the Maturity Parameters of Avocados from the Kiepersol/Hazyview Area

F.J. Kruger, P.J.C. Stassen and B. Snijders
Institute for Tropical and Subtropical Crops, Private Bag X11208, Nelspruit, 1200, RSA

INTRODUCTION

Quality has always been one of the corner stones of the South African fruit export industry. One aspect of quality control which is of particular importance, is consistency with regard to the supply of physiologically mature fruit. For this reason certain techniques have been developed to test and classify fruit. Various methods have been proposed for judging the maturity level of avocado fruit. Attempts have been made to calculate picking dates based on, amongst others, oil content, moisture content, fruit size, dry weight, weight loss, specific gravity, seed coat thickness, sugar content, ripening time as well as electrical, optical and ultrasonic methods (Lee, 1981).

South African farmers and cooperatives tend to make use of moisture content as an indicator of maturity. The inverse relationship between oil and moisture concentrations of avocado fruit has been demonstrated as early as the 1930's (Stahl, 1933). Due to the procedure for moisture concentration calculations being considerably more simple and substantially cheaper than those for measuring oil content, methods have been developed locally to determine moisture content and to deduce oil content from the latter (Swarts, 1976).

In an attempt to upgrade quality control, the management of the Burpak Cooperative in the Hazyview district of the Eastern Transvaal recently decided to supplement moisture content readings with oil content. This paper primarily deals with the relationship between the oil and moisture readings taken at the above cooperative from April to August 1994; the aim being to evaluate whether moisture content can be used as a reliable indicator of oil content.

During the above period a limited number of firmometric readings were also taken and preliminary results as to the relationship between the firmness of the fruit and its oil/water concentration is reported on as well.

MATERIALS AND METHODS

Sampling

Sampling was done on all batches of fruit that were delivered to the cooperative between April and August 1994. Samples of 6 fruit were randomly drawn from each batch. The sample was recorded according to cultivar, delivery date, producer and count.

Moisture concentration assay

Moisture concentration analysis was done on all fruit from each of the 1165 samples that were taken. A 10 g specimen was cut from each fruit and the microwave oven method of Swarts (1976) used to dehydrate the material.

Oil concentration assay

Due to time and labour constraints oil concentration assays could only be performed on 578 samples during the season. However, an attempt was made to obtain a representative cross section of samples of each cultivar. Oil concentration assays were performed on 1 gram of dehydrated specimen, utilising a Soxtec HT6 System (Tecator) and employing the instructions of the manufacturer.

The oil content was expressed in two ways namely, a percentage based on the dry mass as well as a percentage based on fresh fruit mass.

Firmometer readings

Firmometer readings only commenced relatively late in the season. Due to this, readings were only obtained for 29 Hass, 36 Edranol and 55 Ryan samples. The firmometer designed by Swarts (1981) was used for this purpose.

RESULTS

Cultivars

The periods during which samples of the different cultivars were collected are visually displayed in Figure 1. As may be deduced from the above, samples of Fuerte were the earliest to be examined, followed by Hass, Edranol, Pinkerton, Rinton and Ryan. Of these Hass, Edranol, and Fuerte were studied for a period exceeding 100 days while Rinton and Ryan was available for a short time at the end of the season only. Hass was by far the most abundant cultivar to be examined followed by Fuerte, Edranol and Pinkerton. Relatively few Ryan fruit and a scant number of Rinton made up the balance. The ratios, at which the samples of the different cultivars were taken, should not be seen as representative of the crop ratio.

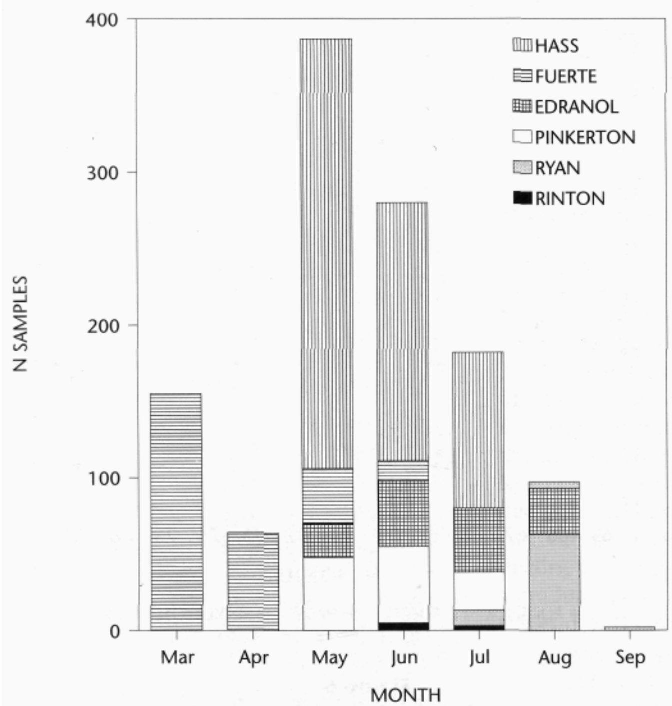

Figure 1
Monthly sampling ratios

Due to the small sample of Rinton that were examined, information on this cultivar is omitted from certain of the data tables and figures to follow.

Producers

Fruit from thirty five producers were analysed. In the case of eleven of the producers, only one cultivar was examined while samples of two cultivars were obtained from 10 farmers. Four farmers each supplied samples of 3 or 4 cultivars respectively, whereas samples of 5 cultivars were obtained from 5 farmers. Only one producer could supply samples of all six cultivars. The 5 biggest producers supplied approximately 50% of all samples examined in the current study.

Counts

The mean count per month of each cultivar is displayed in Figure 2.

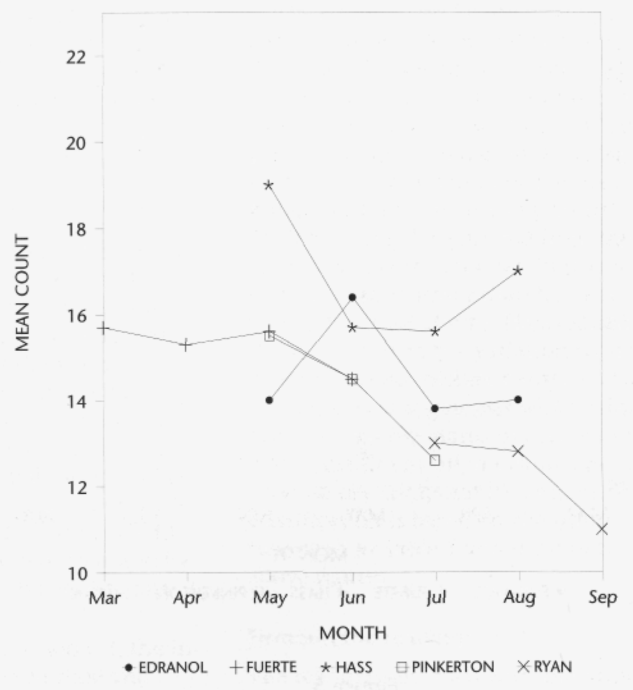

Figure 2
Mean monthly count per cultivar

The counts for the samples of Hass fruit were consistently higher than those of the other cultivars, except for June when the count of this cultivar was comparable with Edranol which in turn exhibited a fluctuating pattern.

It is interesting to note that, although samples of Fuerte, Pinkerton and Ryan were obtained from consecutive but overlapping periods, it would appear that the counts overlapped each other at the beginning and end of each period and that the count-pattern of the three cultivars formed a continuous declining configuration.

Certain preliminary observations were made regarding the relationship between the count of the fruit and the oil and moisture content. These observations are, however, not cited in the current paper. The reason being that we are of the opinion that this seasons data is first to be compared with that of forthcoming seasons before accurate deductions can be made.

Moisture content

The mean moisture content of each cultivar is presented in Table 1. Generally, moisture content displayed a declining pattern as the season progressed (Figure 3). At the beginning of the season the first Fuerte fruit to be marketed had a moisture content of around 78% while the last fruit to be produced, namely Ryan which was delivered in September, had a moisture content around 65%. All cultivars demonstrated an initial sharp decline in moisture content followed by a gradual tailing off of the decline rate at the end of the season.

Table 1

Cultivar specific seasonal means for oil content, moisture content and firmometer reading.

Cultivar		% Moisture	% Oil (dry mass basis)	% Oil (wet mass basis)	Firmometer
Hass	N	565	338	338	29
	x	71,3	54,2	16,1	26,4
	SD	3,9	6,6	3,5	13,8
Fuerte	N	265	25	25	—
	x	75,3	59,5	17,9	—
	SD	3,9	5,4	3,6	—
Edranol	N	139	95	95	36
	x	72,8	59,7	16,8	29,1
	SD	3,8	5,3	3,2	10,0
Pinkerton	N	123	69	69	—
	x	73,0	53,4	14,5	—
	SD	3,2	6,0	2,9	—
Ryan	N	65	45	45	55
	x	66,1	59,1	20,3	30,5
	SD	3,6	6,4	4,2	11,0
Rinton	N	8	6	6	—
	x	71,1	52,2	14,9	—
	SD	2,6	4,3	0,9	—

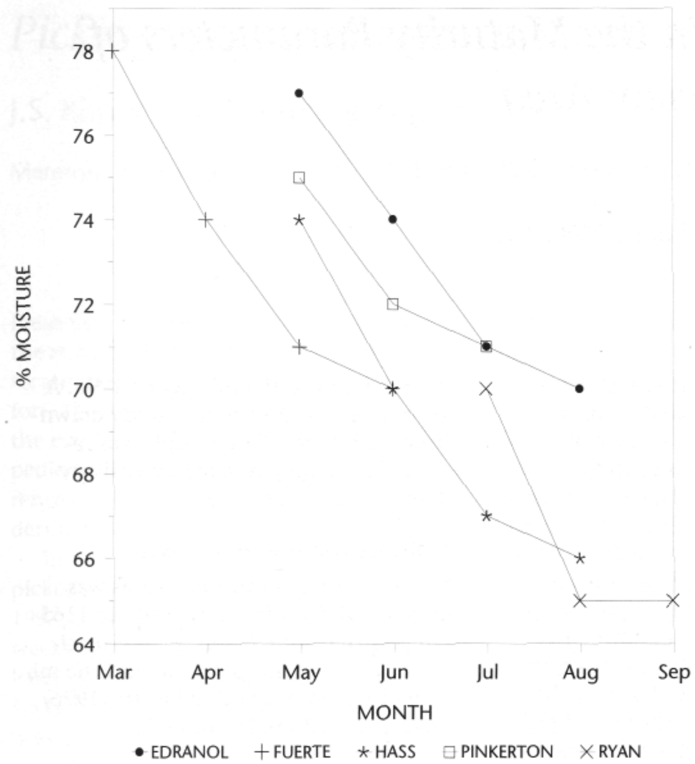

Figure 3
Mean monthly moisture content per cultivar

As may be observed in Table 2, the inverse relationship between time and moisture content was significant, except in the case of Rinton where too few samples were taken.

Table 2
Relationship between delivery date, oil concentration, moisture concentration and fruit firmness

Cultivar			*% Oil (dry mass basis)*	*% Oil (wet mass basis)*	*% Moisture*	*Firmometer*
Hass	Date	N	338	338	565	29
		R	0,484	0,378	-0,535	0,104
		P	0,0001	0,0001	0,0001	0,589
	% Oil (dry mass basis)	N		338	338	19
		R		0,817	-0,648	-0,673
		P		0,0001	0,0001	0,006
	% Oil (wet mass basis)	N			338	19
		R			-0,923	-0,204
		P			0,0001	0,403
	% Moisture	N				29
		R				0.004
		P				0,982
Fuerte	Date	N	25	25	265	—
		R	0,342	0,545	-0,686	—
		P	0,064	0,005	0,0001	—
	% Oil (dry mass basis)	N		25	25	—
		R		0,866	-0,659	—
		P		0,0001	0,0001	—
	% Oil (wet mass basis)	N			25	—
		R			-0,934	—
		P			0,0001	—
	% Moisture	N				—
		R				—
		P				—
Edranol	Date	N	95	95	139	36
		R	0,436	0.426	-0,556	0,116
		P	0,0001	0,0001	0,0001	0,502
	% Oil (dry mass basis)	N		95	95	32
		R		0,859	-0,599	0,041
		P		0,0001	0,0001	0,823
	% Oil (wet mass basis)	N			95	32
		R			-0,889	-0,034
		P			0,0001	0,855
	% Moisture	N				36
		R				0,050
		P				0,771
Pinkerton	Date	N	69	69	123	—
		R	0,493	0,533	-0,469	—
		P	0,0001	0,0001	0,0001	—
	% Oil (dry mass basis)	N		69	69	—
		R		0,830	-0,441	—
		P		0,0001	0,0002	—
	% Oil (wet mass basis)	N			69	—
		R			-0,782	—
		P			0,0001	—
Ryan	Date	N	45	45	65	55
		R	-0,117	0,173	-0,398	0,545
		P	0,530	0,256	0,0010	0,0001
	%Oil (dry mass basis)	N		45	45	39
		R		0,945	-0,794	0,032
		P		0,0001	0,0001	0,862
	% Oil (wet mass basis)	N			45	39
		R			-0,86	0,039
		P			0,0001	0,659
Rinton	Date	N	6	6	8	—
		R	-0,309	0,21	-0,339	—
		P	0,552	0,703	0,410	—
	% Oil (dry mass basis)	N		6	6	—
		R		0,154	0,758	—
		P		0,769	0,080	—
	% Oil (wet mass basis)	N			6	—
		R			-0,526	—
		P			0,284	—

Oil content

Table 2 indicates a statistically significant relationship between date and oil content with regard to Hass, Fuerte, Edranol and Pinkerton. In the case of Ryan and Rinton the relationship was not significant, most probably due to the small size of the samples involved.

As may be observed from Figures 4 and 5, the oil content of all cultivars rose steadily throughout the season. The lowest recorded oil levels (circa 12% wet weight for Edranol & Pinkerton and circa 50% dry weight for Hass & Pinkerton) were recorded during May. The highest oil percentages recorded exceeded 20% of the wet weight (Fuerte in June, and Hass & Ryan in August) and 60% of the dry weight (Fuerte in June, and Hass & Edranol in August).

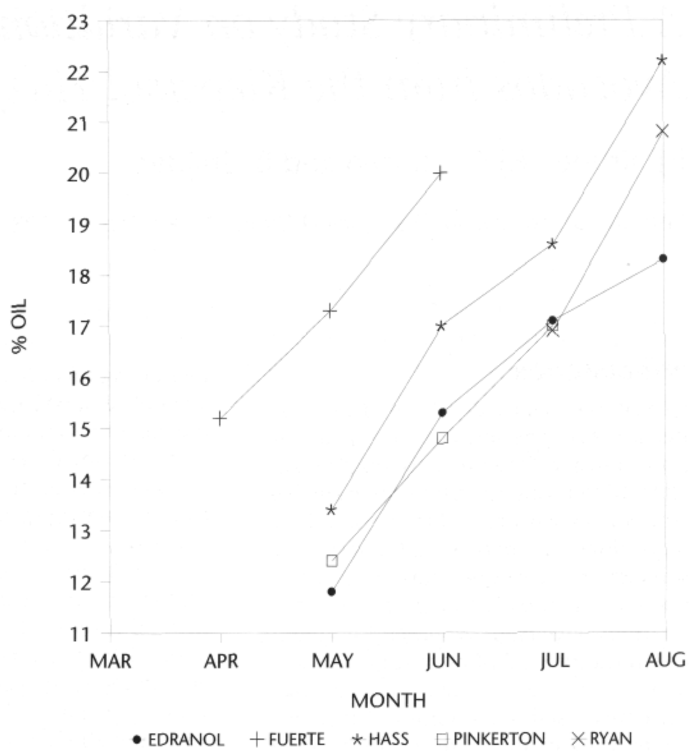

Figure 4
Mean monthly oil content (wet mass basis) per cultivar

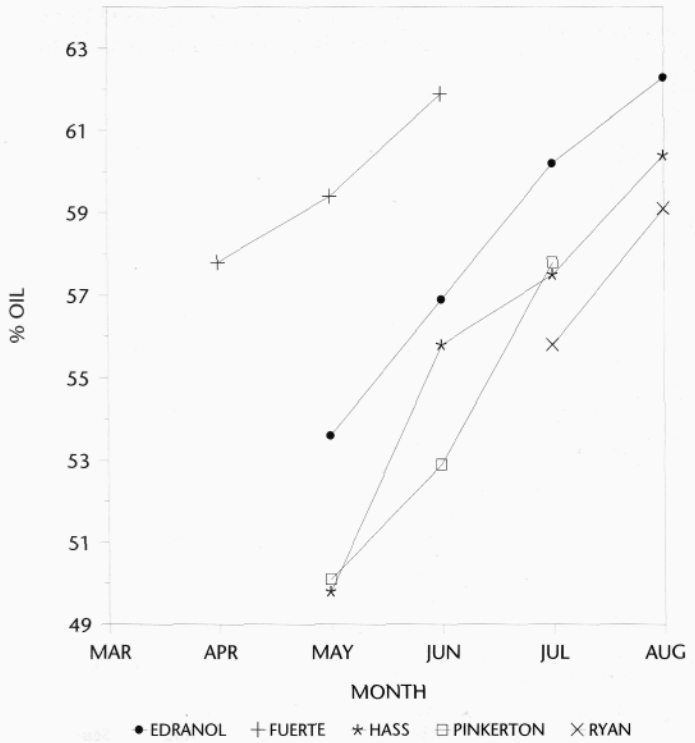

Figure 5
Mean monthly oil content (dry mass basis) per cultivar

Relationship between moisture, oil and fibre content.

The correlation coefficients which describe the relationship between the oil and water contents of the various cultivars are recorded in Table 2. As may be deduced from the latter table, a reverse relationship exists between the two characteristics. In all cultivars, except Rinton where too few samples were available, the relationship was significant. The relationship between the oil content (wet mass basis) and moisture content is visually displayed on a monthly basis in Figure 6 and the linear regression in Figure 7 (dry mass basis). It is interesting to note that, although the intercepts and inclines varied, no cultivar could be regarded as an outlier. However, similar graphs based on dry mass oil content (Figures 8 & 9) indicated that two groups exist. Edranol and Fuerte having greater concentrations of both oil and moisture than Hass, Pinkerton and Ryan.

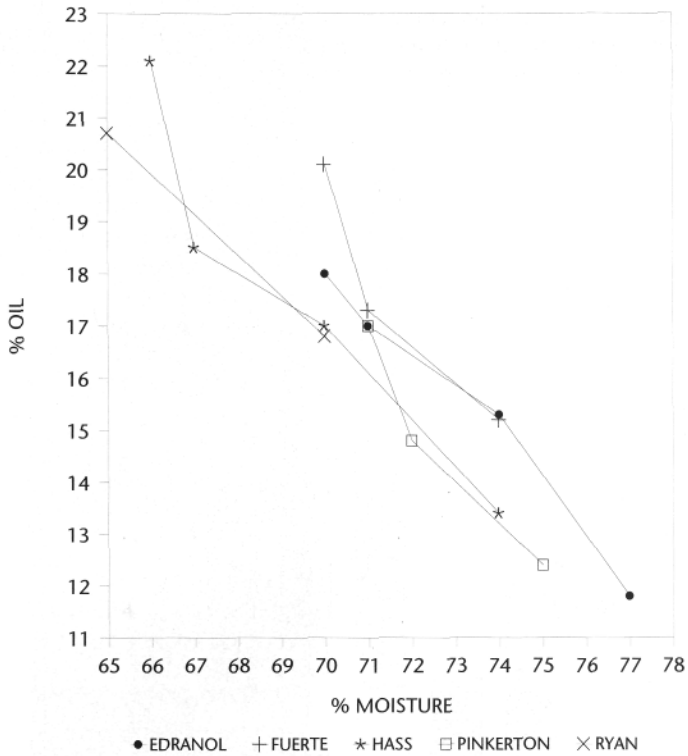

Figure 6
Relationship between oil content (wet mass basis) and moisture content

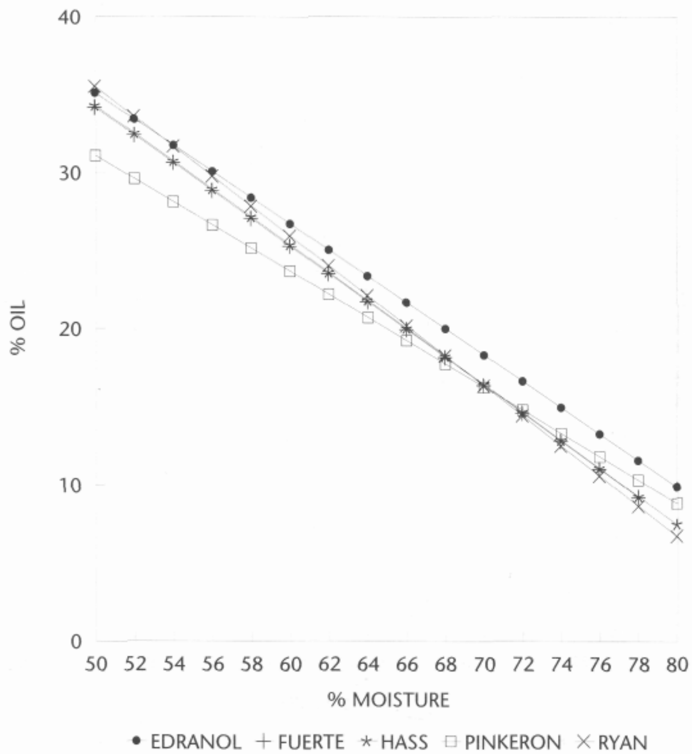

Figure 7

Linear regression between oil content (wet mass basis) and moisture content

Edranol: y = 77,16 –0,84 (x) R^2 = 0,791 P = 0,0001

Fuerte: y = 80,56 – 0,89 (x) R^2 = 0,872 P = 0,0001

Hass: y = 78,98 – 0.89 (x) R2 = 0,852 P 0,0001

Pinkerton: y = 68,19 – 0.74 (x) R2 + 0,612 P = 0,0001

Ryan: y = 76,40 – 0,85 (x) R2 = 0,795 P = 0,0001

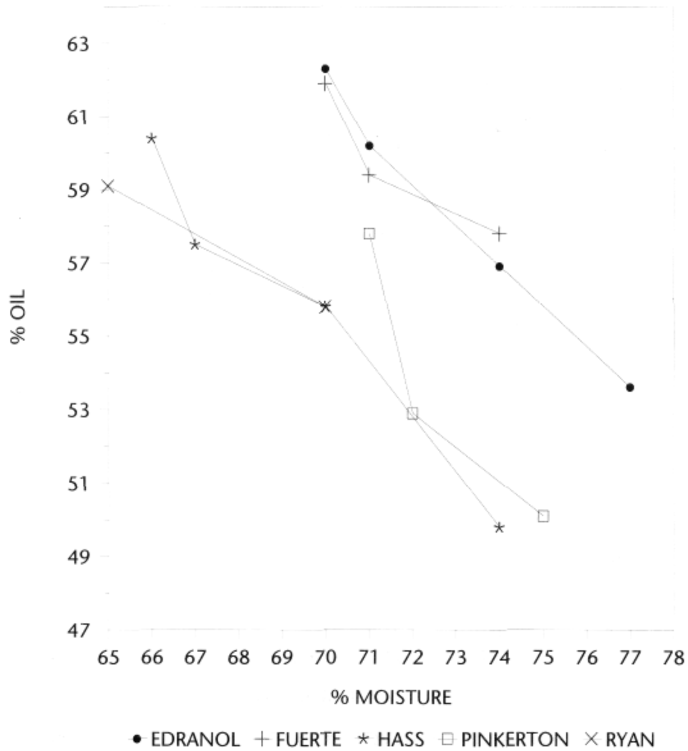

Figure 8
Relationship between oil content (dry mass basis)
and moisture content

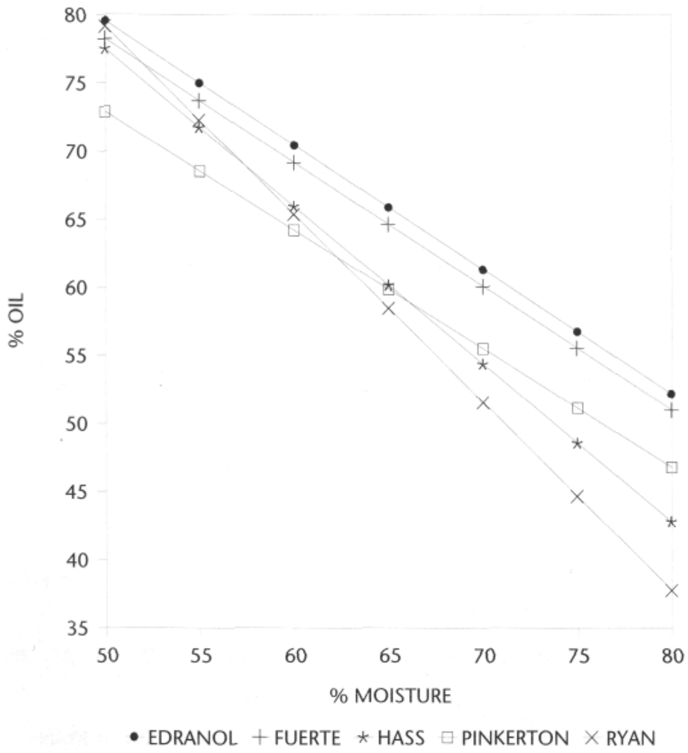

Figure 9
Linear regression between oil content (dry mass basis) and moisture content.
Edranol: y = 125,16 – 0,91 (x) R2 = 0,358 P = 0,0001
Fuerte: y = 123,63 – 0,91 (x) R2 = 0,435 P = 0,0001
Hass: y = 135,37 – 1,16 (x) R2 = 0,420 P = 0.0001
Pinkerton: y = 116,39 – 0,87 (x) R2 = 0,195 P = 0,0002
Ryan: y = 149,14 – 1,38 (x) R2 = 0,631 P 0,0001

The mean oil + water constants of the various cultivars are exhibited in Table 3 and the monthly variation depicted in Figure 10. Also in the table are the oil + water constants obtained by Swart (1976). As may be gathered from the latter, the constants obtained in this study were uniformly lower than those recorded by Swart (1976). Hass exhibited the greatest monthly variation with regard to the oil:moisture constant (1:79).

Table 3
Relationship between the oil and moisture calculations of this study and the constants of Swart (1976)

Cultivar	*Current Study*		*Swart 1976*	
	Constant	*SD*	*Constant*	*SD*
Fuerte	88,2	1,3	89,8	0,6
Edranol	88,6	1,5	90,9	0,9
Hass	86,5	1,4	87,8	0,4
Zutano	—	—	90,7	1,3
Pinkerton	86,9	1,9	—	—
Ryan	85,9	1,5	—	—
Rinton	86,18	1,2	—	—

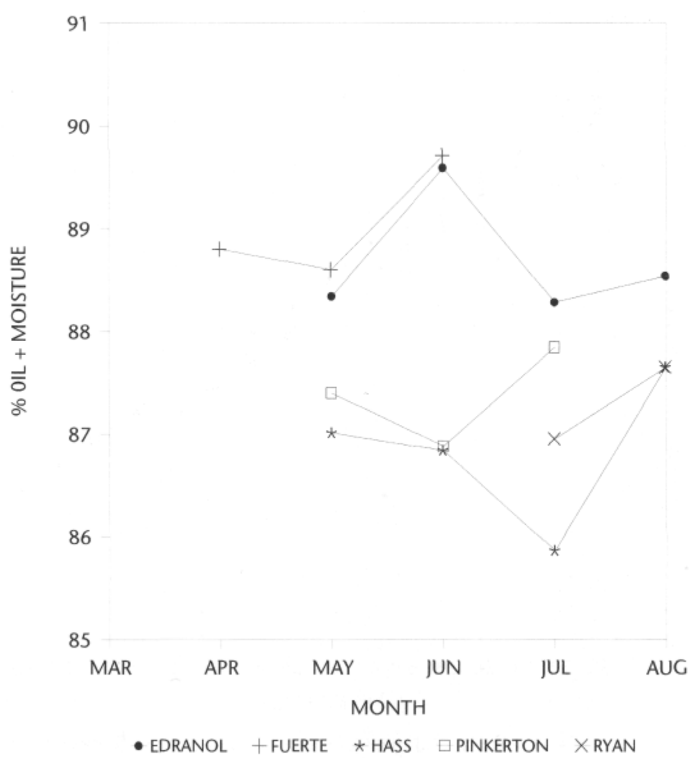

Figure 10
Monthly variation in the oil + water constants of the various cultivars

Figure 11 is a synopsis which indicates the relative status of each cultivar with regard to its oil, moisture and 'fibre' (non oil dry component) content. The classification is based on the information cited in Table 1 and most of the above figures.

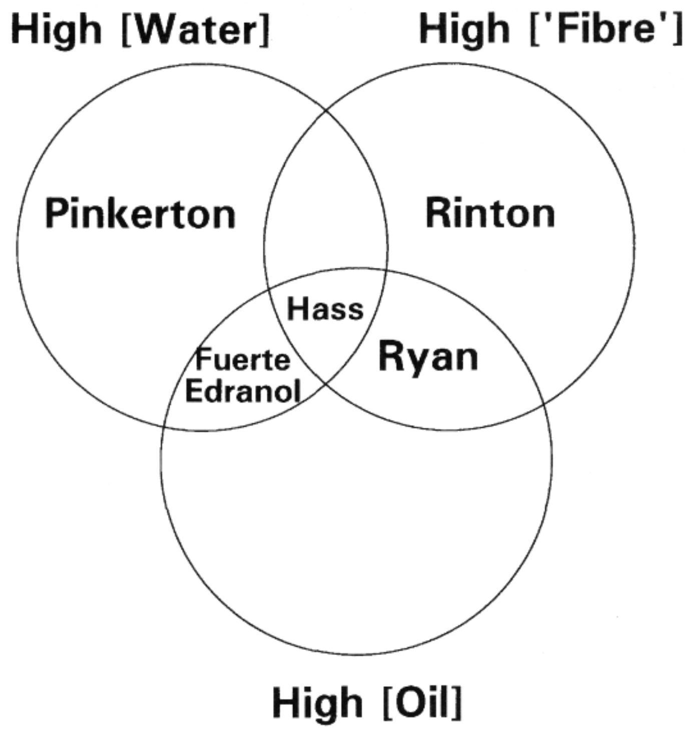

Figure 11
Relative status of each cultivar with regards to its oil, moisture and 'fibre' (non oil dry) components.

Firmometric readings

The readings recorded with the firmometer are delineated in Table 1. The relationship between the firmometer readings and the other variables are exhibited in Table 2. No significant relationship could be demonstrated between the firmometer readings and the oil or moisture content of the fruit. However, a significant relationship existed between the firmometer readings and the date on which Ryan fruit were supplied, indicating that the fruit that were delivered to the cooperative became softer as the season progressed.

DISCUSSION AND CONCLUSION

The results obtained with regard to oil concentration, indicate that all samples from all cultivars that were delivered to the cooperative during 1994, were well above the historically accepted maturity indicator level of 8%. Various researchers have, however, previously stressed that geographic and cultivar specific guidelines should be researched and formulated. For instance, cultivar specific oil concentrations ranging between 7% and 19% have been formulated for avocado in Israel (Gazit & Spodheim, 1969).

The maximum moisture levels at which the avocados were accepted at Burpak in 1994 were 77% in the case of Hass and 80% with regard to all the other cultivars. When making use of Swarts (1976) constants, this converts to a minimum required oil level (fresh mass based) of between 9.8% and 10.9%, depending on the cultivar. However, the constants obtained in this study and those obtained by Holzapfel and Kuschke (1977) are lower than those calculated by Swarts (1976). When using the minimum monthly constants obtained in the current study the above figures equate to a oil percentage between 6,1% and 8,6%. Clearly, a potential error thus exists with regard to the conversions.

Cultivar and geographically specific moisture levels have been suggested to improve moisture to oil conversions. For instance, Van den Dool and Wolstenholme (1983) suggested that in the KwaZulu/Natal midlands the moisture content of Fuerte, Edranol and Hass should be below 77%, 73% and 70% respectively.

An aspect which may have greater implications than the minimum required standards, when considering moisture to oil conversions, is transport temperature. For example, avocado fruit with a moisture content of 77% are transported at 7,5°C, while fruit with a moisture content of 74% are transported at 5,5°C. When using the linear equation on which the regression in Figure 7 is based, both Ryan with a moisture content of 74% and Edranol with a moisture content of 77% equate to a wet oil content around 12,4%. Both batches of fruit should actually thus be sent at the same temperature when oil is taken as the parameter of maturity. It would therefore appear as if oil concentration assays may be safer than moisture assays.

The conception exists with farmers, inspectors and packing managers that in contrast with oil levels, moisture levels of avocado fruit do not decline uniformly as the fruit ripens. It is postulated that the moisture level fluctuates as the result of changes in the soil water level. Interestingly, when comparing the standard deviations with the means in the present study, it is evident that moisture content fluctuated proportionately less than the oil content. On the other hand, it should be kept in mind that 1994 was a dry year in Hazyview and virtually no rain fell during the harvesting season. However, the cultivar specific variation with regard to the moisture content, oil content and non-oil dry content recorded in this study indicate that it is probably more accurate to use dry weight oil concentration as indicator of maturity than wet weight. We thus agree with Kaiser and Wolstenholme (1993), who researched late hanging of fruit that caution should be taken when interpreting data obtained on a wet mass basis only.

From the preliminary results obtained it would seem that the firmometer has little value as an instrument to determine avocado physiological maturity. No significant correlation was found between the latter and the parameters which are currently in use. The readings did, however, indicate that the avocado became softer as the season progressed and a structured study incorporating this instrument before and after cold storage as an indicator of eating ripeness is planned for the coming season.

Although useful information has been obtained, the data contained in this report should be seen as ground-work for a more comprehensive study. Future studies should be combined with cold storage and organoleptic trials in an attempt to make useful deductions. For instance, due to variability in road and sea transport temperatures, it is difficult to set a safe maximum limit to oil concentration. However, this facet is one of the crucial aspects to be researched. Future studies on oil and moisture levels will therefore be combined with cold storage simulations and organoleptic trials.

ACKNOWLEDGEMENTS

The authors would like to thank Amelda Hearn and Daan Jacobs of Burpak as well as Martie van der Walt, Adrian Toerien, Hannes Breedt and Werner Schroeder of the ITSC for their valuable contributions towards this study.

REFERENCES

GAZIT, S. & SPODHEIM, R. 1969. Fruit ripening, a. determining of picking date. In: *The Division of Subtropical Horticulture.* The Volcani Institute of Agricultural Research, 1960 - 1969.

HOLZAPFEL, W.H. & KUSCHKE, E. 1977. Oliebepalings as aanduiding van die rypheid van avokados. *South African Avocado Growers' Association Yearbook.* Supplement: Proceedings of the Technical Committee, 29 - 34.

KAISER, C. & WOLSTENHOLME B.N. 1993. Aspects of late hung Hass avocado *(Persea Americana* Mill.) fruit in the KwaZulu/Natal midlands I. Fruit lipid and fatty acid accumulation. *South African Avocado Growers' Association Yearbook* 16: 39 - 45.

LEE, S. 1981. A review and background of the avocado maturity standard. *California Avocado Society Yearbook* 65: 101 - 109.

STAHL, A.L. 1933. Avocado maturity studies. *Florida State Horticultural Society* 46: 123-133

SWARTS, D.H. 1976. 'n Praktiese avokado-oliebepalingsmetode vir produsente. *The Citrus and Subtropical Fruit Journal* 511*:* 8 - 14.

SWARTS, D.H. 1981. Fermometer ondersoeke by avokado's. *South African Avocado Growers' Association Yearbook* 4: 42 - 46.

VAN DEN DOOL B. & WOLSTENHOLME B.N. 1983. Further studies on avocado fruit growth and maturity in inland Natal. *South African Avocado Growers' Association Yearbook* 6: 34 - 40.