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SEASONAL CHANGES IN THE COMPOSITION OF AVOCADO OIL RECOVERED BY CENTRIFUGATION

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OPSOMMING

Gedurende die 1978-seisoen is avokados van vier kultivars maandeliks verkry en die olie is d.m.v. 'n sentrifugeerproses gefsoleer. Die olieen voginhoud van die vrugmesokarp is maandeliks ontleed en die vetsuursamestelling, fosfolipiedinhoud, jodiumwaardes en vry-vetsuurinhoud van die geisoleerde olie is gereeld bepaal. Olie van verskillende kultivars het beperkte onderlinge verskille in vetsuurpatrone vertoon en die patrone het met verloop van die groeiseisoen verandering ondergaan. Die vetsuurgegewens van plaaslike olies is ook met die van oorsese olies vergelyk.

SUMMARY

Fruit of four avocado cultivars was obtained monthly during the 1978 season. The oil was recovered by centrifugation and the oil and moisture contents of the fruit mesocarp were determined monthly. The fatty acid composition, phospholipid content, iodine values and free fatty acid contents of the oils obtained were determined regularly. Oils from different cultivars exhibited small differences in the fatty acid composition but these compositions changed with time. The fatty acid composition of local oils was also compared with that of overseas oils.

INTRODUCTION

Several publications dealing with the chemical composition of avocado oil have already appeared (Biale *et al.,* 1971; Kikuta, 1968; Slater *et al.,* 1975; Mazliak, 1971) but in no case has there been a comprehensive investigation dealing with the seasonal changes on the composition of avocado oil derived from different cultivars. Analyses on locally produced fruit have been done by Pearson (1975) and Swarts (1976), but these investigations dealt only with the approximate composition.

For the present investigation the cultivars Fuerte, Hass, Edranol and Ryan, harvested during the 1978 season, were supplied by the Letaba Co-operation. Since it had been established that the fruit of these cultivars had been obtained from different trees in a large orchard, additional samples derived from a single tree grown in Pretoria (cultivar unknown) during the same season, were also obtained.

PROCEDURE

Recovery of avocado oil

Avocados of the Fuerte cultivar were obtained monthly from the Letaba Co-operation. The fruits were fully ripened at approximately 30°C. The mesocarp of approximately 5,5 Kg fruit was passed through a pulper-finisher of mesh 0,3 mm and in this way approximately 5 Kg of de-fibred pulp was obtained.

The pulp was heated to a temperature of approximately 45°C in a double-walled container prior to the addition of 300 g sodium chloride (7,5% w/w). The pulp was then further held at this temperature for 2h with stirring at regular intervals, after which it was diluted seven-fold (w/w) with warm water at 80°C. The diluted pulp suspension was then centrifuged in a Westfalia separator (LWA 205) in which the solids were separated from the oil and water fractions. After the passage of approximately 3,2 Kg pulp suspension, the centrifuge was rinsed with approximately 300 ml warm water to displace the oil in the rotor, which was then dismantled to remove the solid material.

After passing all the pulp through the centrifuge, the resulting oil was mixed and stirred with an equal volume of water at 80°C. The oil was then separated from the aqueous phase by centrifugation in a rotor which had been modified because of the absence of solid material. The oil was then filtered through a 3/400 mesh Seitz filter, after which its mass was determined.

A sample of fresh mesocarp was used for the determination of moisture and oil contents, by means of drying in a vacuum oven, and soxhlet extraction, respectively using the methods of the AOAC (1975).

Avocado fruits were also obtained monthly from a tree growing in Pretoria. The mesocarp of approx. 4 fully ripe fruits was sliced into cubes, and 1 Kg of this material was freeze-dried. Two hundred g of the dried mesocarp was extracted for 2 h with 1,5L petroleum ether using a rotary Shaker, after which the extract was filtered. The solid residue was re-extracted for 30 min. with 500 ml petroleum ether, and the extract filtered. The pooled filtrates were concentrated under vacuum in a rotary evaporator to remove the solvent completely. Moisture and oil contents were determined monthly on a sample of fresh mesocarp.

Fatty Acid Composition

The fatty acid composition of the avocado oil of both the Pretoria and Letaba fruits was determined by means of gas-liquid chromatography. A Hewlett-Packard 5750 instrument with double glass columns having dimensions 2,4 m x 2 mm, and equipped with double flame ionization detectors was used for these determinations. The columns were filled with a 6 cm precolumn of 12,5% DEGS (Supelco unstabilized material) on Chromosorb W, followed by 4% DEGS (Analabs stabilized) on Chromosorb G. The oven temperature was isothermically maintained at 185°C, and an inlet and detector temperature of 250°C was used. The nitrogen carrier gas flow rate was 20 ml per min. and integration of the peak areas was performed with the aid of a Hewlett-Packard 3352 computer. Identification of the fatty acid esters was established by means of comparison with Nu Chek Prep fatty acid standards.

The avocado oil was converted to the methyl esters by adding 2 ml 0,025 M sodium methoxide, in dry methanol ta.0,1 g oil and heating at 60°C for 20 min. with frequent shaking. The reaction was completed when the oil droplets dissolved in the alcohol phase. The excess sodium methoxide was neutralized with formic acid and the fatty acid esters extracted with n-heptane.

Phospholipid Content

A modification of the method of Borgström (1952) was employed for the determination of the total phospholipid content of avocado oil. Silica gel (Mallinckrodt) was prepared by washing firstly with methanol, then with chloroform, and was then dried at 110°C. Eight g Silica gel was then added to 5 g oil, dissolved in 50 ml chloroform and the mixture was gently shaken for 10 min. The silica gel was collected by means of a sintered glass funnel, and was washed once with 40 ml chloroform and then three times with 20 ml chloroform. The phospholipid fraction was extracted from the Silica gel with methanol, and the Silica gel was removed by filtration using Whatman 40 filter paper. The Silica gel was washed once with methanol, the filtrates were pooled, and the methanol was removed by means of a rotary evaporator (water bath temperature 35°C). The phospholipid fraction was held overnight in a desiccator before determining its mass.

Free Fatty Acid and Iodine Values

The free fatty acid content of all the oil samples was determined by the AOAC method. The iodine values of all the oil samples was calculated from the fatty acid composition, with the exception of the Fuerte series oil where the Wijs method (AOAC) was also used.

RESULTS

Seasonal changes in moisture, oil and total solids content of the mesocarp of the different avocado cultivars are shown in Table 1 and Figure 1. The oil yield, as obtained by centrifugation of the mesocarp, is shown in Table 2 and Figure 2. The bar diagram in Figure 2 shows the oil content of the avocado mesocarp as well as the percentage oil recoverable by means of centrifugation. The seasonal changes in the fatty acid composition of all the avocado oils is given in Table 3 and the accompanying Figures (Figures 3, 4 and 5). The free fatty acid content and phospholipid content of the oil of Fuerte, Edranol, Ryan and Hass cultivars is shown in Tables 4 and 5, respectively. The iodine values were calculated from the fatty acid composition (Table 3) of each oil (Solms, 1973), and the results are shown in Table 6. The iodine values of the Fuerte series oils as determined by the Wijs method, are also shown in Table 6.

TABLE 1: Seasonal changes in moisture, oil and solids content of avocado mesocarp (g/100g)

FUERTE

	5 April	15 May	30 May	21 June	27 July	22 Aug	27 June*
Moisture	74,9	70,4	68,6	63,7	67,7	59,0	64,0
Oil	15,0	20,1	22,1	27,5	24,7	30,7	29,0
Total solids	10,1	9,5	9,3	8,8	7,6	10,3	7,0

	EDRANOL			RYAN			HASS
	28 June	28 July	24 Aug	31 July	28 Aug	6 Oct	23 Aug
Moisture	76,2	66,7	67,8	71,4	65,5	64,2	64,6
Oil	14,7	24,7	23,5	19,8	24,4	22,1	23,9
Total solids	9,1	8,6	8,7	8,8	10,1	13,7	11,5

PRETORIA TREE

	19 April	8 May	13 June	10 July	7 Aug	10 Sept
Moisture	83,8	80,4	75,9	75,3	69,3	66,4
Oil	5,1	7,1	8,9	11,3	17,2	19,5
Total solids	11,1	12,5	15,2	13,4	13,5	14,1

*Over-ripe fruit of 21st June

TABLE 2: Recovery of avocado oil by laboratory scale centrifugation of mesocarp (expressed as mass percentage of oil content)

FUERTE

	5 April	15 May	30 May	21 June	27 July	22 Aug	27 June*
Recovery (%)	54	54	57	63	59	63	65

	EDRANOL			RYAN			HASS
	28 June	28 July	24 Aug	31 July	28 Aug	6 Oct	23 Aug
Recovery (%)	68	63	64	63	55	78	60

*Over-ripe fruit from 21st June

TABLE 3: Seasonal changes of the fatty acid composition of Fuerte, Edranol, Ryan and Hass avocado oil (g fatty acid/100g fatty acids)

Fatty acid / Oil	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic	Linolenic	Total
FUERTE							
5 April	20,5	7,5	0,8	58,4	11,9	0,7	99,8
15 May	18,2	6,3	0,9	64,5	9,6	0,6	100,1
30 May	17,2	6,0	0,8	66,9	8,6	0,5	100,0
21 June	14,2	4,3	0,7	72,1	7,9	0,5	99,7
27 July	16,7	5,7	0,8	68,1	8,0	0,4	99,7
22 Aug.	31,2	4,4	0,7	72,1	8,8	0,5	99,7
EDRANOL							
28 June	22,4	9,6	0,8	54,4	11,8	0,7	99,7
28 July	19,4	9,4	0,6	60,0	9,5	0,5	99,4
24 Aug.	18,5	8,0	0,7	62,3	9,7	0,5	99,7
RYAN							
31 July	22,3	10,6	0,6	55,0	10,0	0,7	99,2
28 Aug.	15,2	5,2	0,7	63,8	13,8	0,9	99,6
6 Oct.	13,1	3,5	0,7	66,4	15,2	0,6	99,5
HASS							
23 Aug.	21,6	11,8	0,5	50,6	13,8	0,8	99,4

All the oils contained traces (0,1 — 0,3%) myristic, heptadecenoic, icosanoic and icocenoic acids.

TABLE 4: Changes in the free fatty acid content of Fuerte, Edranol, Ryan and Hass avocado oil during the 1978 season (%)

FUERTE					
5 April	15 May	30 May	21 June	27 July	22 Aug
0,42	0,19	0,09	0,06	0,06	0,07

EDRANOL			RYAN			HASS
28 June	28 July	24 Aug	31 July	28 Aug	6 Oct	23 Aug
0,1	0,06	0,06	0,08	0,1	4,69	0,09

TABLE 5: Changes in the phospholipid content of Fuerte, Edranol, Ryan and Hass avocado oil during the 1978 season (g phospholipids/100g)

FUERTE					
5 April	15 May	30 May	21 June	27 July	22 Aug
2,5	0,8	0,8	0,6	0,7	0,4

EDRANOL			RYAN			HASS
28 June	28 July	24 Aug	31 July	28 Aug	6 Oct	23 Aug
0,5	0,3	0,4	0,3	0,3	0,7	0,4

PRETORIA SERIES					
19 April	8 May	13 June	10 July	7 Aug	10 Sept.
7,2	5,7	5,1	5,5	4,0	6,6

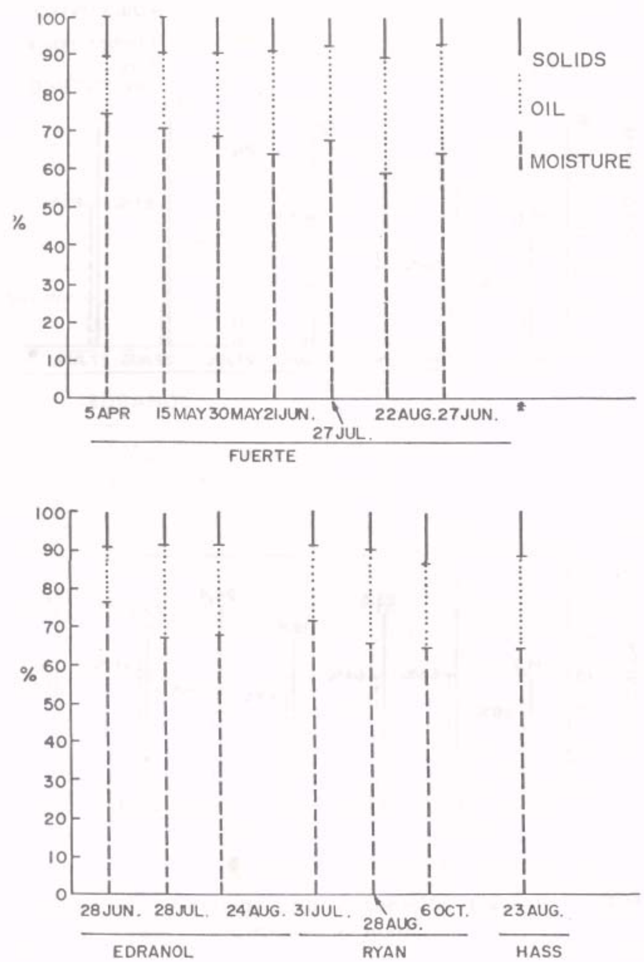

FIG. 1: Seasonal changes in the solids, oil and moisture contents of avocado mesocarp of four cultivars from Letaba (g/100g)

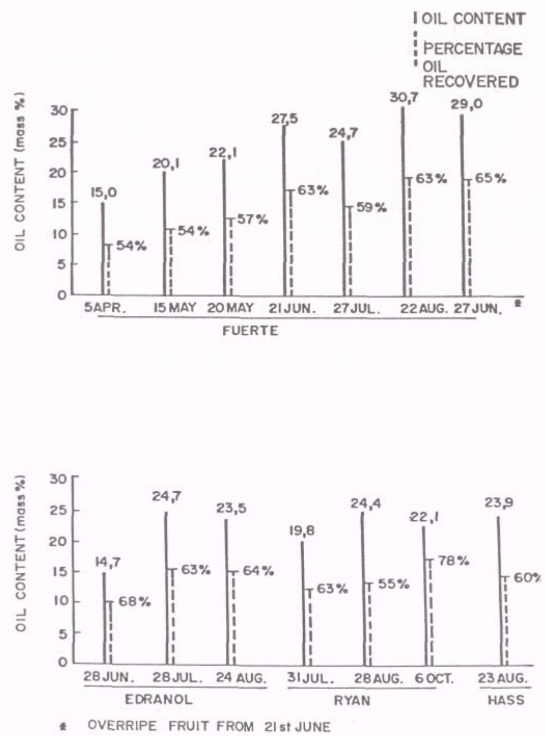

FIG. 2: Recovery of avocado oil by laboratory scale centrifugation of mesocarp

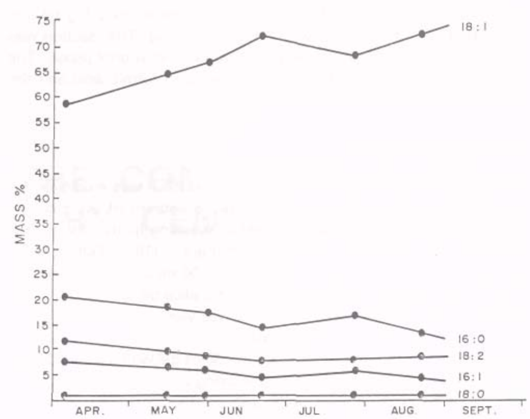

FIG. 3: Seasonal changes of the fatty acid patterns of avocado oil from Letaba Fuerte fruit

DISCUSSION

Oil, Moisture and Solids Content

The inversely proportional relationship which exists between the oil and moisture contents of avocado mesocarp (Slater *et al.* 1975) was confirmed in the present study (Table 1 and Figure 1). The oil content of Fuerte mesocarp almost doubled during the five-month period, while the moisture content decreased accordingly. In the case of Edranol fruits the oil content increased over the three-month period, but the value was not doubled. The Ryan fruits showed the smallest increases in oil content; because only one consignment of Hass fruit was received it was not possible to observe any seasonal changes.

Swarts (1976) established that the sum of the oil and moisture contents of ripe Fuerte fruits should be approximately 89,8. Consequently a comparison of the sum of oil and moisture contents of the different cultivars is given in Table 7.

It was found that the constant value of Fuerte fruit of the 5th April and 22nd August agreed well with the theoretical constant of 89,8, but that higher values were obtained in the case of all four samples over the period of 15th May to 27th July. Furthermore, it is noteworthy that over-ripe fruits (27th June) yielded a much higher constant value.

The constant value for Edranol fruit was determined as 90,9 by Swarts (1976) and in the present study the average value over the three-month period was found to be 91,2. There was little variation in the values over the three-month period (Table 7). The constant values of Ryan fruit decreased sharply over the three-month period and large variations from the average value 89,1 were noted. Swarts (1976) determined a constant value of 87,8 for the Hass cultivar, and the value of 88,5 obtained for this cultivar in the present study is in good agreement with that value.

Recovery of Oil

Lower oil recoveries were obtained from Fuerte fruits at the beginning than at the end of the season (Figure 2). The impression was gained that fruits with a lower oil content also yielded lower recoveries of oil. It is also noteworthy that over-ripe fruits (27th June) did not yield significantly higher recoveries as compared to normal ripe fruits (21st June). Edranol and Ryan fruits yielded oil recoveries of over 60% at the start of the picking season when the oil content was low. The Ryan fruits of 6th October yielded an exceptionally high recovery figure. Although it is not possible to explain this result in the light of available information, it may be speculated that increased enzyme activity in the pump was responsible for the high oil values. This view is based on the fact that a very high free fatty acid content was found in the same sample (Table 4), indicating a high lipase activity.

The most important general conclusion to be made from the recovery figures is that between 54 and 65% (average 62%) of the oil may be isolated by laboratory-scale centrifugation. This figure ought to be improved by centrifuging larger quantities of pulp. It was observed that considerable amounts of oil were lost in the centrifugation and filtration processes.

Fatty Acid Composition

The fatty acid composition of avocado oil is unique not only in that a particularly low stearic acid content is found, but also that palmitoleic acid occurs as a component of the oil. The seasonal changes of the two main components of the oil of the Fuerte series

(Figure 3), oleic and palmitoleic acids, indicate that oleic acid increases whereas palmitic acid decreases.

The non-linear curves in Figure 3 are the result of variations in the results obtained for fruits collected during June and July. It is noteworthy that the oil from the Pretoria tree also showed an increase in oleic acid and a decrease in palmitic acid, but in this case nearly linear curves were obtained (Figure 5);

In the case of both series of oils a decrease in linoleic acid was observed from April to June, but from June to July a small increase was observed.

The changes in the fatty acid composition of the oils of Edranol, Ryan and Hass cultivars were similar to that of Fuerte oil (Table 3). Edranol oil showed a slight increase in oleic acid (18:1) over the three-month period but palmitic acid (16:0) decreased and palmitoleic (16:1), linoleic (18:2) and stearic (18:0) acids remained nearly constant (Figure 4). A sharp increase in oleic and linoleic acids was observed in the case of Ryan oil, while palmitic and palmitoleic acids decreased accordingly (Figure 4). The fatty acid composition of Hass oil compared well with that of the oils of Fuerte, Edranol and Ryan cultivars, taken at the start of their harvesting season.

TABLE 6: Changes in the iodine values of Fuerte, Edranol, Ryan and Hass avocado oil during the 1978 season

	FUERTE					
	5 April	15 May	30 May	21 June	27 July	22 Aug
Calculated	79,4	79,3	79,1	80,7	78,5	82,4
Wijs determined	83,0	78,9	78,8	78,5	73,6	82,8

	EDRANOL			RYAN			HASS
	28 June	28 July	24 Aug	31 July	28 Aug	6 Oct	23 Aug
Calculated	81,8	81,9	82,9	80,0	90,0	93,4	84,4

TABLE 7: Sum of oil and moisture contents of avocado mesocarp of different cultivars during the 1978 season

FUERTE						
5 April	15 May	30 May	21 June	27 July	22 Aug	27 June[+]
89,9	90,5	90,7	91,2	92,4	89,7	93,0

EDRANOL			RYAN			HASS
28 June	28 July	24 Aug	31 July	28 Aug	6 Oct	23 Aug
90,9	91,4	91,3	91,2	89,9	86,3	88,5

PRETORIA TREE					
19 April	8 May	13 June	10 July	7 Aug	10 Sept
88,9	87,5	84,8	86,6	86,5	85,9

TABLE 8: Ratio of unsaturated to saturated fatty acids in Fuerte and Hass oil from California and Letaba

	FUERTE		HASS	
	Calif.	Letaba	Calif.	Letaba
Total unsaturates:	87,7	82,4	90,0	77,0
Total saturates:	12,3	17,5	10,2	22,1
Ratio:	7,1	4,7	8,8	3,5

A comparison of the seasonal changes in the fatty acid composition of the Fuerte and Pretoria series of oils (Figures 3 and 5) reveals that sampling is a very important factor, and that fruits should preferably be picked from one tree only, and that variation in the degree of ripeness should be eliminated.

The fatty acid composition of the oil of Fuerte and Hass avocados from California differs from that of the locally grown cultivars (Slater *et al.* 1975). The ratio of unsaturated to saturated fatty acids may be calculated and this serves as basis for comparison (Table 8). The locally produced oils from Fuerte and Hass cultivars are relatively poorer in unsaturated, but richer in saturated fatty acids.

Iodine Values

The calculated and Wijs iodine values for the Fuerte series are shown in Table 6. It may be seen that the calculated values show less variation than the Wijs values. Both sets of iodine values confirm that the Fuerte oil maintained approximately the same degree of unsaturation with the passage of time. The calculated iodine value for Californian Fuerte oil is 87,7 which is 7,8 units higher than the average iodine value of local Fuerte oil

(79,9). Similarly, the calculated iodine value for Californian Hass oil is 88,6 and this exceeds the value for local Hass oil (84,4) by 4,2 units.

The iodine values of Edranol oil showed a small increase from 81,8 to 82,9 over the three-month period. In contrast, Ryan oil showed a drastic increase from 80,0 to 93,4. Of the four cultivars investigated Ryan oil yielded the highest iodine value, and is therefore the most unsaturated local oil.

Free Fatty Acid and Phospholipid Contents

The free fatty acid content of all the oils was low (Table 4) and values of 0,1% or less were obtained for 10 oils. However, a high value was recorded for Fuerte oil obtained on the 5th April, and an exceptionally high value was recorded for Ryan oil obtained on the 6th October. These high free fatty acid values are most probably due to an increased lipase activity in the pulp. In the proposed local specification for edible oils and fats a free fatty acid value of 0,1% at the point of manufacture is stipulated. This specification should be achieved quite easily with centrifuged avocado oil.

Fuerte oil of the 5th April had an exceptionally high phospholipid content, as compared to all the other centrifuged oils (Table 5). The other oils had values of between 0,3 and 0,8% and no clear seasonal trends in the phospholipid contents could be detected. A phospholipid content of 1,3% was found in the case of avocado oil which was extracted from the mesocarp with solvents (Kikuta, 1968). Similarly, phospholipid values of 4,0% to 7,2% (Table 5) were obtained for the avocado oil extracted from the fruit of the Pretoria tree. These results indicate that avocado oil obtained by centrifugation has a lower phospholipid content than oil obtained by extraction with solvents.

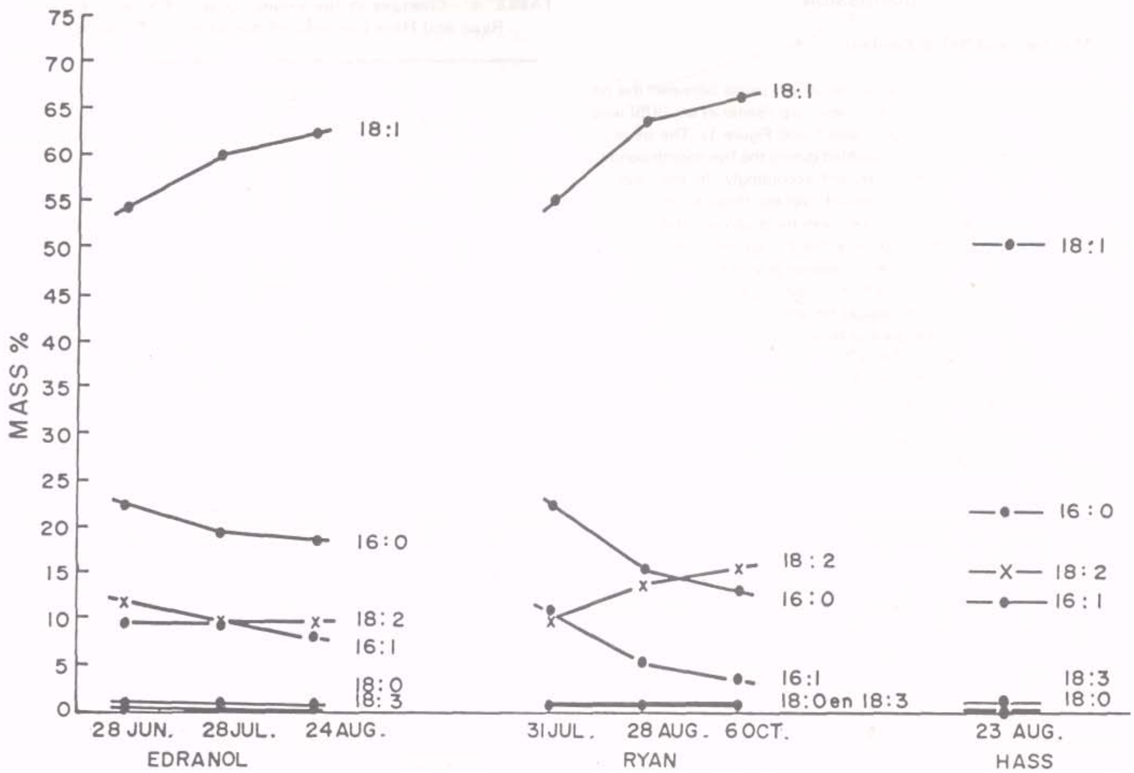

FIG. 4: Seasonal changes of the fatty acid patterns of Edranol and Ryan avocado oil

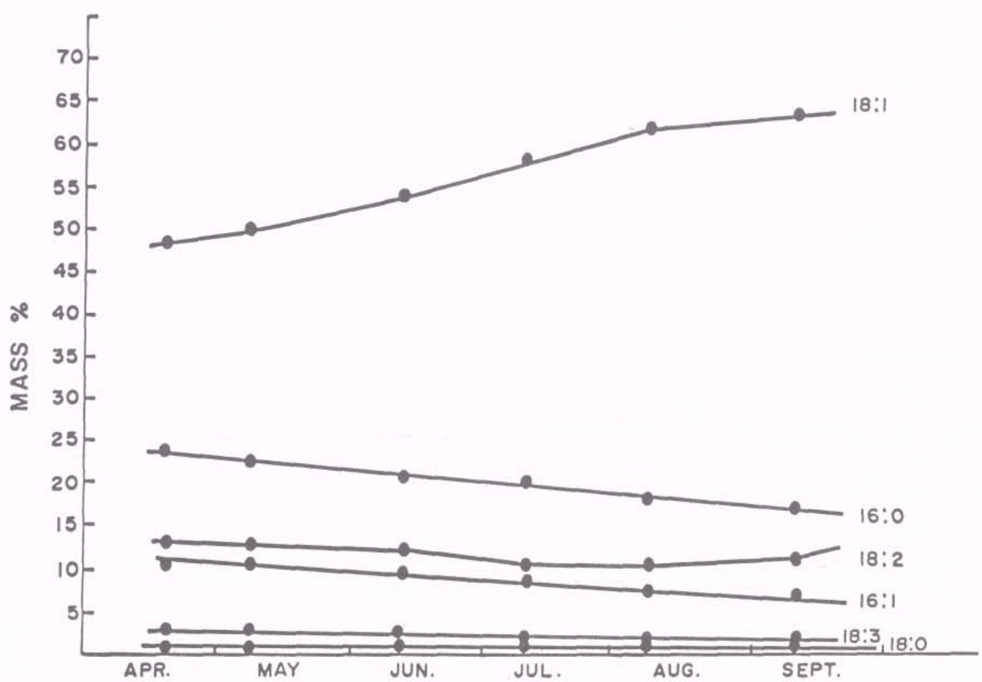

FIG. 5: Seasonal changes of the fatty acid pattern of avocado oil extracted from Pretoria avocados

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