Phytochemistry, Vol. 26, No. 6, pp. 1595–1597, 1987.
Printed in Great Britain.

0031-9422/87 $3.00 + 0.00

TRIGLYCERIDE AND FATTY ACID COMPOSITIONS IN THE MESOCARP OF *PERSEA AMERICANA* DURING FRUIT DEVELOPMENT

EMILE M. GAYDOU, YVES LOZANO* and JULIE RATOVOHERY

Laboratoire de Phytochimie, Ecole Supérieure de Chimie de Marseille, Rue H. Poincaré, 13397 Marseille Cédex 13, France; *Laboratoire de Biochimie Technologie des Produits Végétaux Tropicaux, CIRAD-IRFA-Centre INRA-Domaine Saint Paul, 84140 Montfavet, France

(*Received* 21 *July* 1986)

Key Word Index—*Persea americana*; Lauraceae; triglycerides; fatty acids; development.

Abstract—The moisture and lipid contents and fatty acid and triglyceride (TG) compositions of mesocarp of developing avocado fruits (*Persea americana*, Lula variety) were studied. The moisture content decreased steadily with increasing lipid content during the 12–39 weeks after flowering (WAF). In the early stage (12 WAF), the fatty acids and TGs represent the minor amount of the lipid fraction (13%). As the fruits developed, the fatty acid and TG contents increased to 88 and 85%, respectively, at 36 WAF. Thereafter, the fatty acid level remained unchanged and the TG level decreased to 72%. No significant change in fatty acid balance was observed from 16 to 39 WAF. On the other hand, the linoleyl oleyl palmitin + dioleyl palmitolein content increased while the triolein and dioleylpalmitin content decreased as the fruits matured. The fatty acid and TG composition of Lula variety were markedly different from those of other varieties.

INTRODUCTION

The avocado (*Persea americana* Mill.) is an oleaginous fruit and some varieties, such as Fuerte, Hass and Lula, have considerable commercial importance. The changes in the classes of lipids associated with the development of avocado fruit has been discussed recently [1]. The lipid content and the fatty acid composition of variety Fuerte have been reported [2–4]. Mesocarp oil is characterized by having a high content (50–60%) of oleic acid. Although the neutral lipids, phospholipids, free fatty acids and hydrocarbons contents of some varieties have been studied [5–7], the triglyceride (TG) composition of mesocarp lipids has been investigated only after separation of the molecular species by TLC and GC [8], by silver nitrate TLC and pancreatic lipolysis [9], or by HPLC [10]. In the present study, we have followed the accumulation of lipids as well as the fatty acid and TG compositions of the mesocarp lipids during development of avocado fruits of the Lula variety.

RESULTS AND DISCUSSION

The accumulation of lipids and the changes in fatty acid and TG compositions were followed from 12 weeks after flowering (WAF) to 39 WAF. During the 25 WAF, the fruits increased greatly in weight (120–400 g), in length (90–120 mm) and in diameter (56–84 mm). After 25 WAF and up until 39 WAF, these parameters remained more or less the same (weight, 450–500 g; length, 125–130 mm; diameter, 85–90 mm). The moisture content (Table 1) decreased gradually from 85% to 67%. Similar changes in moisture content have been observed in the Hass and Fuerte varieties [11]. The total lipids, on the other hand, increased smoothly from 2.7% of the fresh weight to a maximum of 18.5%. The final concentration of lipids in this study is comparable to earlier reports [1–4]. Quantitative determination of total fatty acids contained in the lipids was improved by using an internal standard (Table 1). The fatty acid content increased rapidly until 25 WAF from 13% of total lipids to 83% and, thereafter

Table 1. Moisture and lipid contents of mesocarp of developing avocado fruits (wt %)

Time after flowering (weeks)	Moisture (% fr. wt)	Total lipids (% fr. wt)	Fatty acids (% total lipids)	Triglycerides (% total lipids)
12	84.7	2.7	13.3	12.6
16	84.1	4.6	47.9	50.8
20	81.3	7.4	74.4	83.1
25	79.9	9.0	82.6	84.9
31	76.7	12.5	84.9	82.5
36	69.2	14.3	88.0	85.1
39	66.8	18.5	87.2	72.5

remained at about the same amount (85–88%). Similar results were observed for TG. As the avocado fruits developed, more and more TG was accumulated and reached a maximum of *ca* 85% by 25 WAF. It remained roughly at the same level until 36 WAF and thereafter decreased at 39 WAF to 72.5%. These results are quite different from those obtained for the Hass variety since the authors [8] found 51% TG, 29% diglyceride and 7% monoglyceride. A study of the other components of the lipid fraction is in progress.

The fatty acid composition of mesocarp lipids from different WAF is given in Table 2. Among the unsaturated acids, oleic acid (18:1) was present in the highest amounts (43–47%), followed by linoleic acid (18:2, 15–22%) and palmitoleic acid (16:1, 5–12%). Palmitic acid (16:0) was the only saturated fatty acid present in significant amounts. No significant change in fatty acid composition was observed between 16 and 39 WAF. During the first 12 WAF, a higher content of an unknown substance (3.3%), linolenic (18:3, 3.7%) and linoleic (22.2%) acids and a lower content of palmitoleic acid (5.4%) were observed. These results differ from those obtained for the Fuerte variety [12] since palmitic, palmitoleic and linoleic acids increased only slightly while the major change was a large increase in oleic acid.

Several authors [10, 13–18] have reported on the separation of TGs by HPLC with a reversed-phase C18 column. Using similar conditions, we obtained ten peaks which between them were shown to contain 13 TG molecular species. The TG composition of the lipids is given in Table 3. Dilinoleyl palmitin (LLP), linoleyl oleyl palmitin (LOP) and linoleyl dipalmitin (LPP) were not separated by HPLC, from linoleyl oleyl palmitolein (LOPo), dioleylpalmitolein (OOPo) and oleyl palmityl palmitolein (OPPo), respectively. LOP + OOPo increased gradually from 19 to 30% during the period 16–39 WAF. A similar change in the case of LPP + OPPo, LLP + LOPo and OPP was also observed until 31–36 WAF. Triolein (OOO) and dioleyl palmitin (OOP) decreased smoothly from 16 to 7–8% and from 22 to 16–17%, respectively. Similar behaviour was observed for the two minor TGs, LLPo and LPPo. The final TG composition of the avocado variety that we have studied in this work is quite different from that of the Fuerte variety [10]. The fatty acid composition of the Fuerte variety is mainly composed of oleic acid (60%) and the major TGs are LOO (11%), LOP + OPPo (16%), OOO (18%) and OOP (24%) [10].

Table 2. Fatty acid composition (% total) of mesocarp of avocado fruits

Fatty acids	Time after flowering (weeks)						
	12	16	20	25	31	36	39
16:0	22.4	25.4	25.9	26.3	28.4	26.0	25.6
16:1Δ7	5.4	9.5	10.8	12.0	12.1	12.1	12.0
18:0	0.9	0.8	0.7	0.7	0.7	0.7	0.7
18:1Δ9	42.2	47.5	46.3	45.2	43.7	44.0	45.6
18:2Δ6, 9	22.2	15.1	14.9	14.8	14.4	16.2	15.2
Unknown*	3.3	0.2	0.3	0.1	0.1	0.1	0.1
18:3Δ3, 6, 9	3.7	1.5	1.1	0.9	0.6	0.9	0.7

*Unidentified compound found during analyses of fatty acid methyl esters by GC.

Table 3. Triglyceride composition of mesocarp of developing avocado fruits

Triglycerides*	Time after flowering (weeks)						
	12	16	20	25	31	36	39
LLPo	3.5	2.6	2.3	2.5	1.5	1.9	1.8
LPPo	2.2	1.7	0.8	0.9	0.8	0.7	0.5
LLO	7.6	9.2	7.7	8.0	5.0	8.3	7.8
LLP + LOPo	6.1	9.7	9.1	10.1	9.7	10.7	9.2
LOO	13.2	12.4	13.6	11.1	7.7	11.8	11.1
LOP + OOPo	20.2	18.7	22.5	24.4	30.0	27.8	30.3
LPP + OPPo	4.2	5.6	7.2	7.7	7.8	7.5	6.0
OOO	15.8	11.7	9.4	7.7	7.8	7.4	8.8
OOP	21.6	20.0	19.1	19.1	19.9	16.3	16.8
OPP	5.6	8.3	8.3	8.5	9.8	7.6	7.7

*Abbreviations: L, linoleic acid (18:2Δ6,9); Po, palmitoleic acid (16:1Δ7); P, palmitic acid (16:0); O, oleic acid (18:1Δ9); LLPo, dilinoleylpalmitoleine; OOO, trioleine.

EXPERIMENTAL

Avocado trees (*Persea americana*, var. Lula) were grown in the Station de Recherches Agronomiques de Martinique (CIRAD-IRFA). About ten fruits were harvested in 1983 at different intervals after flowering and analyses were done 48 hr after harvesting. Moisture was determined by lyophilization and lipids were extracted from powdered mesocarp with hexane in a Soxhlet apparatus for 8 hr.

Fatty acid analysis. For quantification on a mass basis, an appropriate amount of an internal standard (heptadecanoic Me ester) was added to the extracted lipids. Fatty acid Me esters were prepared by *trans*-methylation according to ref. [19] and analysed by FID-GC with a Carbowax 20 M glass capillary column (25 m × 0.3 mm). Analyses were carried out isothermally at 190° with H_2 as carrier gas (flow rate 50 ml/min). The amounts of fatty acids were determined by comparison with the peak area of the internal standard (17:0).

HPLC separation of TGs. A Spectra-physics model SP 8000B pump combined with a Shodex model RI.SE.11 differential refractometric detector was used. TG separation was accomplished on a 4.6 × 250 mm column packed with Lichrosorb RP 18 (5 μ, Merck). Lipids (1–2 drops) were dissolved in Me_2CO (1 ml) and injected onto the column (20 μl). The elution was performed using MeCN–Me_2CO–THF (58:38:4) at a flow rate of 1.5 ml/min. To calibrate the column and to determine the quantity of TG molecular species, pure tripalmitin and triolein were injected before the first analytical runs.

Acknowledgements—This work was supported in part by the Fonds d'Aide de Coopération (France) and by a research grant from the C.I.E.S. for J.R. Technical assistance in collecting fruits was provided by M. Chaupin and M. Cottin.

REFERENCES

1. Ahmed, E. M. and Barmore, C. R. (1980) in *Tropical and Subtropical Fruits* (Nagy, S. and Shaw, P. E., eds), p. 121. Avi, West Port, CT.
2. Mazliak, P. (1971) *Fruits* **26**, 615.
3. Mazliak, P. (1965) *Fruits* **20**, 117.
4. Mazliak, P. (1971) in *The Biochemistry of Fruits and their Products* Vol. 2, pp. 1–63 (Hulme, A. C., ed.). Academic Press, London.
5. Gutfinger, T. and Letan, A. (1974) *Lipids* **9**, 658.
6. Tango, J. S., Da Costa, S. I., Antunes, A. J. and Figueiredo, I. B. (1972) *Fruits* **27**, 143.
7. Petronici, C., Bazan, E., Panno, M. and Averna, V. (1978) *Riv. Ital. Sost. Grasse* **55**, 262.
8. Bazan, E., Panno, M., Petronici, C. and Averna, V. (1981) *Riv. Ital. Sost. Grasse* **58**, 571.
9. Sharma, C. B. and Martinez, G. C. (1972) *J. Am. Oil Chem. Soc.* **49**, 229.
10. Lozano, Y. (1983) *Rev. Fr. Corps Gras* **30**, 333.
11. Slater, G. S., Shaukman, S., Sheperd, J. S. and Alfin-Slater, R. B. (1975) *J. Agric. Food Chem.* **23**, 468.
12. Kikuta, Y. (1968) *J. Fac. Agric. Hokkaido Univ.* **55**, 469.
13. Plattner, R. D., Spencer, G. F. and Kleiman, R. (1977) *J. Am. Oil Chem. Soc.* **54**, 511.
14. Plattner, R. D., Wade, K. and Kleiman, R. (1978) *J. Am. Oil Chem. Soc.* **55**, 381.
15. Plattner, R. D. and Payne-Wahl, K. (1979) *Lipids* **14**, 152.
16. Wada, S., Koizumi, C., Tagikuchi, A. and Nonaka, J. (1978) *Yukagaku* **27**, 579.
17. Bezard, J. A. and Ouedraogo, M. A. (1980) *J. Chromatogr.* **196**, 279.
18. Lie Ken Jie, M. S. F. (1980) *J. Chromatogr.* **192**, 457.
19. Gaydou, E. M., Rasoarahona, J. and Bianchini, J. R., (1983) *J. Sci. Food. Agric.* **34**, 1130.