Food Chemistry **48** (1993) 237–241

Oil content, stability and fatty acid composition of the main varieties of Catalonian hazelnuts (*Corylus avellana* L.)

Josep Serra Bonvehí*

Department of Research and Development of Nutrexpa, S.A. c/Lepanto, 410–414, 08025 Barcelona, Spain

&

Francesc Ventura Coll

IRTA (Centre de Cabrils), 08348 Cabrils (Barcelona), Spain

(Received 30 September 1992; revised version received and accepted 8 February 1993)

The oil content, stability and fatty acid composition were determined in the main varieties of Catalonian hazelnuts (Negret, Pauetet, Gironell, Grifoll, Culplà and Morell). Packed column gas and capillary chromatography and the Rancimat method were used. The percentage of oil, its stability and linoleic acid content were found to depend on the variety and farming method (dry farming or irrigation). A difference of 43% in the results obtained for oil stability was detected, the Culplà variety showing the greatest stability and Negret the least. The Negret variety also presented the greatest variance in linoleic acid content, ranging from 11·70% to 20·10%. Irrigation reduces the oil content, increases the percentage of linoleic acid and reduces stability in most varieties.

INTRODUCTION

Hazel cultivation in Spain is based in the province of Tarragona (Catalonia). Traditional single cropping is used and there are two different agronomical and climatological areas: a dry-farming area of 15 600 ha and an irrigated area of 13 800 ha. These areas produce nearly 17 000 MT (unshelled), representing 87% of national production (Ministerio de Agricultura, 1988).

The high oil content of nuts and oleaginous seeds is well known, spheromes usually containing a large part of the oil. Among the neutral lipids, the triglycerides are particularly important because they are major components of oils and natural fats (Bazan *et al.*, 1975). The unsaturated fatty acid content of the hazelnut makes it a nutritional product, but also makes it more susceptible to auto-oxidation (Frankel, 1991). Therefore it is necessary to know the fatty acid composition because of its relationship with hazelnut quality. During the development of the hazelnut, three phases can be distinguished: in the first, each hazelnut accumulates a certain amount of oil; in the second, there is a sharp increase; and in the third, the accumulation slows until it stabilizes (Fregoni & Zioni, 1963; Roversi, 1973; Lotti *et al.*, 1985). This behaviour is also found in the almond (Saura Calixto *et al.*, 1984; Soler *et al.*, 1988).

As the hazelnut is gathered once it has fallen to the ground, at its highest point of maturity (Fregoni & Zioni, 1963), the variations which may exist between the hazelnut samples can depend on the variety and farming method (García Olmedo *et al.*, 1979). For these reasons, and to improve their use in the agro-alimentary industry, it was advisable to contribute to the local knowledge of the six main varieties of Catalonian hazelnuts (Negret, Pauetet, Gironell, Morell, Culplà and Grifoll), with the intention of establishing criteria for evaluating product quality, preservation and ageing. Therefore, this study focused on the physical characteristics, lipid, protein, sugars, vitamin and enzyme fractions, and other parameters related to the deterioration of the hazelnut (Serra Bonvehí & Ventura Coll, 1992, 1993*a*,*b*).

MATERIALS AND METHODS

Materials

Twenty-two samples of hazelnuts of the main varieties cultivated using dry farming, irrigation and mixed

* To whom correspondence should be addressed.

Table 1. Hazelnut sampling: site of origin

Sample no.	Variety	Geographical origin	Farming method
1	Morell	Falset	Dry farming
2	Culplà	Falset	Dry farming
3	Morell	Falset	Irrigation
4	Culplà	Falset	Irrigation
5	Negret	Vilaplana	Dry farming
6	Negret	Vilaplana	Irrigation
7	Grifoll	Vilaplana	Dry farming
8	Grifoll	Vilaplana	Irrigation
9	Pauetet	Vila-seca	Irrigation
10	Gironell	Vila-seca	Irrigation
11	Pauetet	Riudoms	Irrigation
12	Gironell	Riudoms	Irrigation
13	Negret	Riudoms	Irrigation
14	Gironell	Riudecols	Irrigation
15	Negret	Riudecols	Dry farming
16	Negret	Reus	Irrigation
17	Gironell	Vilallonga	Irrigation
18	Negret	Vilallonga	Irrigation
19	Gironell	El Morell	Irrigation
20	Negret	El Morell	Irrigation
21	Pauetet	Alcover	Irrigation
22	Culplà	Falset	Dry farming[a]

[a] Biological cultivation.

methods in Tarragona were studied (Table 1). Each sample was made up of 5 kg of in-shell hazelnuts. The samples were artificially dried at an air temperature of approximately 40°C and air flow rate of 1·25 m/s until a shelled hazelnut moisture of less than 5% was obtained. Drying was discontinuous, and reduced water content at a rate of 1% per hour. To complete the process, cold air (5–10°C) was passed through for 60–90 min. The hazelnuts were then preserved at room temperature and in the dark.

Physico-chemical analyses

Oil extraction
Shelled hazelnuts (30 g) were homogenized in a coffee grinder. Triplicate 10-g samples were extracted with petroleum ether (40–60°C) for 6 h using a Soxhlet apparatus. Oil was determined as the difference in weight of dried samples before and after extraction.

Cold rendering of hazelnut oil
Oil was extracted under pressure following the method of Schneeberger *et al.* (1988).

Gas chromatographic analysis
Hazelnut oil was weighed for packed column chromatography (0·25–0·30 g) or for capillary chromatography (0·10 g). Transesterification was carried out in 10 ml of 0·02 N sodium methylate, heated under reflux for 5–10 min until a single phase was obtained. This phase was neutralized with 1·3 N HCl in methanol, and the acids were extracted with 3–4 ml of hexane and transferred into a flask containing a saturated solution of NaCl (Mordret *et al.*, 1987).

Chromatographic conditions
Packed column chromatography was performed on a Perkin–Elmer Sigma 2 GC system with a 2 m × 3 mm i.d. glass column containing 10% of DEGS-PS + 3% OV-225 on Chromosorb W.AW.DMC 80–100 mesh, a flame ionization detector (FID) and a PE Sigma 15 microprocessor. Injector temperature was 210°C; detector temperature was 220°C; column temperature was held at 180°C; carrier gas (N_2) flow rate was 20 ml/min and injection quantity was 2 μl (Beuchat & Worthington, 1978).

Capillary chromatography was performed on a Perkin–Elmer Sigma 2 GC system with an SP-2300 capillary column (30 m × 0·25 mm i.d. with 0·2-μm particle diameter), an FID and PE Sigma 15 microprocessor. Injector temperature was 210°C; detector temperature was 220°C; column temperature was held at 180°C; carrier gas (N_2) flow rate was 1–1·5 ml/min; carrier make-up gas was 60 ml/min and splitter vent flow was 60–70 ml/min; injection quantity was 1 μl.

Stability to oxidation (automated Swift Test with Rancimat)
Approximately 2·5 g of oil extracted under pressure was heated for 10 min at 120°C in the Rancimat heating block (E 617 Rancimat Methrom A.G. model). The dry air feed and the collection vessel were then connected. The measurement of the conductivity curve then started. The breaking point was equal to the induction time (hours) (Hadorn & Zürcher, 1974).

Statistical analyses
Analysis of variance and multiple range LSD test were carried out using the Statgraphics statistical packet, version 4.0 (see Table 6 below).

RESULTS AND DISCUSSION

Tables 2–4 show the oil content, fatty acid composition and stability of the varieties. The same varieties (Negret, Morell, Culplà and Grifoll) cultivated using dry farming and irrigation methods produced different amounts of oil (Table 2). The maximum difference reached was 1·5% between the mean values of the varieties. The standard deviation for each group of varieties is from 0·71 to 3·25, which corresponds to coefficients of variance of 1·07–4·99%. In the same farming area, a maximum difference of 4·6% between the dry farming and irrigation methods was found. The results obtained differ from those of Soliva *et al.* (1983) and Ninot (1985), but coincide with the results of Zürcher and Hadorn (1975) and Hadorn *et al.* (1978). The Tarragona and Italian hazelnut varieties are similar in oil content (Gargano *et al.*, 1982). The Croatian varieties usually have lower oil contents (Ninie & Cerovic, 1987), and the Turkish varieties usually give varied results (Zürcher & Hadorn, 1975; Hadorn & Zürcher, 1977; Hadorn *et al.*, 1977*a*,*b*; Keme *et al.*, 1983*a*,*b*).

Triglycerides are the predominant component of nut oil (>95%, Saura Calixto *et al.*, 1985). They also contain phospholipids and glycolipids at less than 2% (García Olmedo *et al.*, 1979). The unsaponifiable material makes up between 0·10 and 1%. Table 2 shows fatty acid composition of the oil found using packed column and capillary chromatography. No significant differences were found (P = 0·05).

Unsaturated fatty acids are clearly predominant in nuts, the main acids being $C_{18:1}$ and $C_{18:2}$ (Table 3).

Table 2. Fatty acid composition, oil content and stability

Sample no.	Fatty acid composition (%)								Stability (h, at 120°C)	Oil content (g per 100 g)
	$C_{16:0}$	$C_{16:1}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:0}$	$C_{20:1}$		
1	6·50	0·18	1·90	82·0	8·90	tr	0·25	0·22	7·95	65·4
2	6·40	0·29	2·30	83·7	6·80	tr	0·22	0·20	9·55	66·9
3	5·80	0·28	2·10	81·7	9·40	tr	0·28	0·25	7·90	64·3
4	6·00	0·30	2·60	83·1	7·40	tr	0·25	0·21	9·40	65·9
5	5·70	0·16	1·90	75·6	15·9	0·10	0·23	0·21	5·65	66·5
6	5·80	0·16	2·10	78·2	13·2	tr	0·18	0·20	6·15	67·6
7	5·20	0·15	2·10	81·8	10·2	tr	0·25	0·24	6·65	67·4
8	5·18	0·11	2·00	81·9	10·0	tr	0·22	0·20	6·25	62·8
9	6·70	0·40	1·80	80·1	10·3	tr	0·25	0·24	7·25	67·4
10	6·10	0·16	1·70	80·4	11·0	tr	0·23	0·21	6·65	64·8
11	6·10	0·31	1·90	81·9	9·0	tr	0·26	0·21	7·60	66·7
12	5·90	0·29	1·70	79·6	12·0	tr	0·23	0·21	6·50	66·1
13	5·60	0·27	1·70	76·3	15·5	tr	0·24	0·27	5·70	65·7
14	5·90	0·13	1·90	83·0	8·30	tr	0·27	0·23	7·75	66·1
15	6·30	0·42	1·90	79·0	11·7	tr	0·29	0·19	6·75	66·3
16	6·00	0·18	1·90	75·2	16·2	tr	0·18	0·22	5·55	65·1
17	5·80	0·18	1·80	82·1	9·50	tr	0·27	0·26	6·65	64·8
18	6·00	0·19	1·40	74·7	17·0	tr	0·28	0·32	5·05	65·7
19	5·10	0·29	2·10	80·3	11·7	tr	0·18	0·20	7·15	66·1
20	5·70	0·32	1·60	71·4	20·1	tr	0·32	0·40	4·40	65·1
21	6·60	0·20	1·60	81·2	10·0	tr	0·18	0·18	5·85	65·0
22	6·20	0·32	2·20	83·1	7·50	tr	0·17	0·20	8·20	65·4

tr, Trace.

Table 3. Hazelnut fatty acid composition (%)

Variety	$C_{16:0}$		$C_{16:1}$		$C_{18:0}$		$C_{18:1}$		$C_{18:2}$		$C_{18:3}$		$C_{20:1}$		$C_{20:2}$	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Negret	5·86	0·24	0·24	0·10	1·79	0·23	75·8	2·49	15·66	2·70	tr	—	0·25	0·16	0·26	0·13
Dry-farmed	6·00	0·42	0·29	0·18	1·85	0·07	77·3	2·12	13·80	2·70	tr	—	0·16	0·04	0·20	0·01
Irrigated	5·82	0·18	0·22	0·07	1·74	0·27	75·2	2·46	16·36	2·44	tr	—	0·24	0·06	0·28	0·08
Gironell	5·74	0·38	0·21	0·08	1·84	0·17	81·1	1·41	10·50	1·56	tr	—	0·23	0·04	0·22	0·02
Pauetet	6·47	0·32	0·30	0·10	1·76	0·15	81·1	0·91	9·75	0·28	tr	—	0·23	0·04	0·21	0·03
Morell	6·15	0·50	0·23	0·07	2·00	0·14	81·2	0·35	9·15	0·35	tr	—	0·21	0·02	0·21	0·02
Culplà	6·20	0·28	0·30	0·01	2·45	0·21	83·4	0·42	7·01	0·42	tr	—	0·23	0·02	0·20	0·01
Grifoll	5·19	0·10	0·16	0·01	2·00	0·14	81·9	0·14	10·10	0·14	tr	—	0·23	0·02	0·22	0·03

Table 4. Hazelnut oil stability

Variety	Stability (h, at 120°C)				
	$\bar{x}$	SD	$V_{max.}$	$V_{min.}$	Confidence limits (α = 0·05)
Negret	5·61	0·75	6·75	4·40	6·28 — 4·94
Dry-farmed	6·20	0·78	6·75	5·65	6·98 — 5·42
Irrigated	5·37	0·67	6·15	4·40	6·04 — 4·70
Gironell	6·94	0·52	7·75	6·50	7·54 — 6·34
Pauetet	6·90	0·93	7·60	5·85	8·61 — 5·19
Morell	7·90	0·04	7·95	7·90	8·01 — 7·79
Culplà	9·40	0·11	9·55	9·40	9·60 — 9·20
Grifoll	6·45	0·28	6·65	6·25	7·30 — 5·60
Mixture of varieties	6·84	1·30	9·55	4·40	7·42 — 6·26

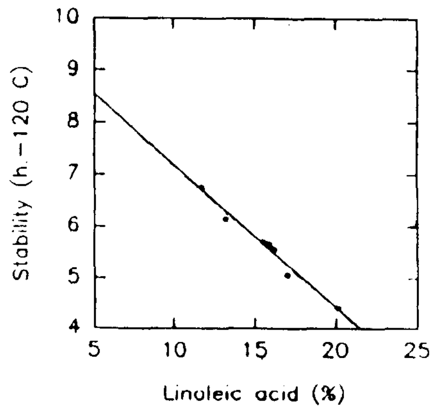

Fig. 1. Correlation between results of the linoleic acid and stability in Negret variety.

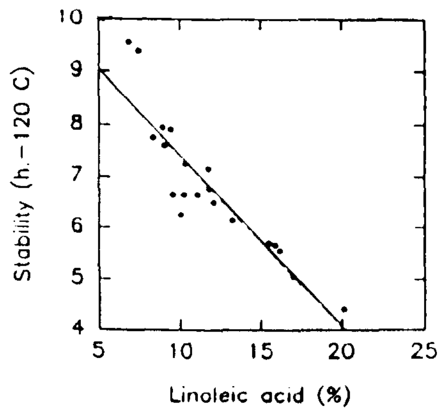

Fig. 2. Correlation between results of the linoleic acid and stability in mixed varieties.

Table 5. Stability and linoleic acid percentage

Parameter	Variety					
	Negret	Gironell	Pauetet	Morell	Culplà	Grifoll
Stability (h, at 120°C)	5·61	6·94	6·90	7·90	9·40	6·45
Linoleic acid (%)	15·7	10·5	9·75	9·15	7·01	10·1

Linoleic acid is present in variable percentages, and is the main cause of the chemical rancidification of the hazelnut, along with other factors such as the peroxidase activity, antioxidant and pro-oxidant components (Heimann & Schreier, 1971; Schreier and Heimann, 1971; Kermasha *et al.*, 1986; Cetin, 1989, Serra Bonvehí & Ventura Coll, 1993*b*). This acid is predominant in the initial stages of fruit formation, whereas later in maturation oleic acid and antioxidant components become predominant (Fregoni & Zioni, 1963, 1965).

Varieties should be used which are low in linoleic acid and rich in antioxidant components, to extend product keeping time and, if possible, to reduce preservation requirements (Keme *et al.*, 1983*a*,*b*; Hlisc, 1986; Coors & Montag, 1988). This aspect is accentuated in irrigated cultivation, where the amount of oil is lower and the linoleic acid percentage is higher (Tables 2 and 3). Our results agree with those of Zürcher and Hadorn (1975), but not with those of García Olmedo *et al.* (1979), Soliva *et al.* (1983) and Ninot (1985). The Negret variety shows the greatest variability of linoleic acid, ranging from 11·7 to 20·1%. Ordering the varieties according to linoleic acid percentage, we detect a variation of 59% from the best variety (Culplà) to the worst (Negret). The percentage of unsaturated fatty acids is normally maintained in the 91–92·5% range, based on average values of the different varieties, and in the 7·4–8·9% range for saturated fatty acids.

From the various tests used to evaluate the stability of acid oxidation—the Schaal Oven Test, the Sylvester Test (automated with the Fira-Astell device) and the Swift Test (automated with the Rancimat)—we have chosen the last one, in accordance with Hadorn and Zürcher (1974) and Gutiérrez Rosales (1989). According to the results in Table 4, a 43% stability difference was detected between Culplà and irrigated Negret, and a 13% difference between dry-farmed Negret and irrigated Negret. Correlating stability with the percentage of linoleic acid in in-shell hazelnut, we obtain a correlation coefficient of r^2 = 0·976 (Negret variety) in Fig. 1 and r^2 = 0·836 (mixed varieties) in Fig. 2.

Table 5 compares the variety, stability and linoleic acid percentage. Despite the fact that the Pauetet variety has a low linoleic acid content (Tables 2 and 5), it has a lower stability than was expected (r_2 = 0·23). This discordance could be due to other factors associated with hazelnuts, such as peroxidase activity and antioxidant components (Cetin, 1989). The Pauetet variety, which shows the highest peroxidase activity (Serra Bonvehí & Ventura Coll, 1993*b*), has a reduced stability because of the action of peroxidase during determination, although this enzyme has great heat stability (Garrote *et al.*, 1985).

The analysis of variance indicates significant differences ($P < 0·05$) between varieties and linoleic acid percentage and stability (Table 6). Farming method had no influence ($P < 0·05$) on any factor. No interaction between variety and farming method was found.

Table 6. Analysis of variance ($P \leq 0·05$)

Parameter	Variety	Farming	Interaction
Oil	—	—	—
Linoleic acid	x	—	—
Stability	x	—	—

CONCLUSION

The Negret variety has the highest linoleic acid content and the lowest stability. The Culplà and Morell mountain varieties are the most resistant to chemical rancidification. The correlation between linoleic acid and stability is good.

ACKNOWLEDGEMENT

We are grateful to Pere Cabré for help in completing the Rancimat analyses.

REFERENCES

Bazan, E., Petronici, C., Panno, M. & Acerna, V. (1975). Distribuzione degli acidi grassi nei trigliceridi dell'olio dei semi di nocciolo (*Corylus avellana* L.). *Riv. Ital. Sostanze Grasse*, **52**, 230–2.

Beuchat, L. R. & Worthington, R. E. (1978). Technical note: fatty acid composition of tree nut oils. *J. Food Technol.*, **13**, 355–8.

Cetin, M. (1989). Änderung der Tocopherol- und Tocotrienolgehalte im Sojaöl und im Haferöl bei der automatisierten Bestimmung der Oxidationsstabilität nach der Rancimat-Methode. *Dtsch Lebensm. Rundschau*, **85**, 390–3.

Coors, U. & Montag, A. (1988). Untersuchungen zur Stabilität des Tocopherolgehaltes pflanzlicher Öle. *Fat Sci. Technol.*, **90**, 129–36.

Frankel, E. N. (1991). Review. Recent advances in lipid oxidation. *J. Sci. Food Agric.*, **54**, 495–511.

Fregoni, M. & Zioni, E. (1963). Influenza dell'epoca e del metodo dui raccolta sulle caratteristiche qualitative delle nocciole. *Frutticoltura*, **8/9**, 651–6.

Fregoni, M. & Zioni, E. (1965). Studio biometrico, botanico-agronomico, merceologico e chimico-industriale sulla cultivar di nocciuolo 'Tonda Piacentina'. *Ind. Agrarie*, **3**, 575–8.

García Olmedo, R., Valls Pallès, C. & Díaz Marquina, A. (1979). Contribución al estudio de los aceites de frutos secos españoles. Características del aceite de avellanas de las distintas variedades de la provincia de Tarragona (Campaña 1976). *Anal. Bromatol.*, **31**, 137–58.

Gargano, A., Magro, A. & Manzo, P. (1982). Caratteristiche chimiche dei frutti di alcune delle principali cultivar di nocciuolo—nota 2". *Ind. Aliment.*, **1**, 45–8.

Garrote, R. L., Silla, E. R. & Bertone, R. A. (1985). Distribución e inactivación térmica de los enzimas peroxidasa y lipoxigenasa en el choclo (*Zea mays*). *Rev. Agroquím. Tecnol. Aliment.*, **25**, 373–83.

Gutiérrez Rosales, F. (1989). Determinación de la estabilidad oxidativa de aceites de oliva vírgenes: comparación entre el método del oxígeno activo (A.O.M.) y el método Rancimat. *Grasas Aceites*, **40**, 1–5.

Hadorn, H. & Zürcher, K. (1974). Zur Bestimmung der Oxydationstabilität von Ölen und Fetten. *Dtsch. Lebensm. Rundschau*, **70**, 57–65.

Hadorn, H. & Zürcher, K. (1977). Nacheilige Veränderungen von Haselnüssen während der Lagerung. *Gordian*, **77**, 114–20.

Hadorn, H., Keme, T., Kleinert, J., Messerli, M. & Zürcher, K. (1977*a*). So verhalten sich Haselnüsse unter verschiedenen Lagerungsbedingungen (I). *Zucker- und Sübwaren Wirtschaft*, **30**, 120–6.

Hadorn, H., Keme, T., Kleinert, J., Messerli, M. & Zürcher, K. (1977*b*). So verhalten sich Haselnüsse unter verschiedenen Langerungsbedingungen (II). *Zucker- und Sübwaren Wirtschaft*, **30**, 170–80.

Hadorn, H., Keme, T., Kleinert, J., Messerli, M. & Zürcher, K. (1978). Lagerungsversuche und Qualitätsprüfungen an Haselnüssen. *Gordian*, **10**, 300–10; **11**, 342–8.

Heimann, W. & Schreier, P. (1971). Uber das Lipoxygenase-'Lipoperoxidase'-System in Cerealien: I. Untersuchung der Reaktiosprodukte. *Helv. Chim. Acta.*, **54**, 2794–802.

Hlisc, T. (1986). Rancidity resistance of filbert cvs. Istrian Oblong, Römische Nuss and Halle. *Zb. Bioteh. Fak. Univ. E.K. Ljubljani*, **47**, 71–6.

Keme, T., Messerli, M., Shejbal, J. & Vitali, F. (1983*a*). The storage of hazelnuts at room temperatures under nitrogen (I). *Rev. Choc. Confect. Bakery*, **8**, 24–8.

Keme, T., Messerli, M., Shejbal, J. & Vitali, F. (1983*b*). The storage of hazelnuts at room temperatures under nitrogen (II). *Rev. Choc. Confect. Bakery*, **8**, 15–20.

Kermasha, S., Van Voort, F. R. & Metche, M. (1986). Conversion of linoleic and hydroperoxide by french bean hydroperoxide isomerase. *J. Food Biochem.*, **10**, 285–303.

Lotti, G., Paradossi, C. & Marchini, F. (1985). La biosintesi dei gliceridi nei semi di *Corylus avellana* durante la maturazione. *Riv. Ital. Sci. Aliment.*, **14**, 279–86.

Ministerio de Agricultura (1988). *Boletín Mensual de Estadística Agraria*. Publicaciones del Ministerio de Agricultura, Pesca y Alimentación, Madrid, No. 12.

Mordret, F., Prévot, A., Perrin, J. L., Coustille, J. C. & Morin, O. (1987). Applications des récents progrès des méthodes chromatographiques à l'analyse des corps gras. *Ann. Fals. Exp. Chim.*, **80**, 9–24.

Ninie, J. T. & Cerovic, S. (1987). The usability of Turkish filbert (*Corylus colurna* L.) fruits. *Jug. Vocartsvo*, **21**, 23–36.

Ninot, A. (1985). Estudi de la conservació de disset varietats d'avellana sotmeses a diferents condicions ambientals per mitjà del control analític de la fracció oliosa. T.F.C. Universitat Politècnica, Lleida, Spain.

Roversi, A. (1973). Rilievi sull'accrescimiento e sull'accumulo in grasso dei frutti di *Corylus avellana* L., *Ann. Fac. Agraria UCSC*, **13**, 318–39.

Saura Calixto, F., Cañellas Mut, J. & Soler, L. (1984). Morphological and compositional changes during development and maturation of the almond (*Prunus amygdalus*). *Agrochimica*, **28**, 175–84.

Saura Calixto, F., Cañellas Mut, J. & Soler, L. (1985). Characteristics and fatty acid composition of almond tegument oil. Comparison with almond kernel oil. *Fette-Seifem-Antrichmittel*, **87**, 4–6.

Schneeberger, R., Villarroel, M. & Arapela, N. (1988). Cinética de extracción de aceite de avellana. *Grasas Aceites*, **39**, 151–4.

Schreier, P. & Heimann, W. (1971). Uber das Lipoxygenase-'Lipoperoxidase'-System in Cerealien: II. Charakterisierung des Hydroperoxyde-abbauenden Enzyms. *Helv. Chim. Acta.*, **54**, 2803–9.

Serra Bonvehí, J. & Ventura Coll, F. (1992). Caractéristiques physiques des principales variétés de noisette (*Corylus avellana* L.) produites dans la province de Tarragone (Espagne). *IAA*, **109**, 23–8.

Serra Bonvehí, J. & Ventura Coll, F. (1993*a*). Study of the carbohydrate fraction of the principal varieties of Tarragona hazelnuts (*Corylus avellana* L.). *Food Chem.*, **46**, 285–8.

Serra Bonvehí, J. & Ventura Coll, F. (1993*b*). Étude de l'activité enzymatique de la lipase, esterase, lipoxygénase, peroxydase et polyphénoloxydase des principales variétés de noisette (*Corylus avellana* L.) de la province de Tarragone (Espagne). *Rev. Fr. Corps Grass.* (in press).

Soler, L., Cañellas, J. & Saura Calixto, F. (1988). Oil content and fatty acid composition of developing almond seeds. *J. Agric. Food Chem.*, **36**, 695–7.

Soliva, M., Serena, C., García, M. D. & Riera, M. (1983). Determination et description de l'huile de l'amandon de differentes variétés de noisetier. *Convegno Inter. Nocciuolo, Avellino*, pp. 527–33.

Zürcher, K. & Hadorn, H. (1975). Qualitätsbeurteilung von Haselnubkernen. *Mitt. Gebiete. Lebensm. Hyg.*, **66**, 191–224.