Chilean Hazelnut (*Gevuina avellana*) Seed Oil

Sir:

There is increased interest in the nuts and seed oil from the Chilean hazelnut (*Gevuina avellana*) (1–3), a tree found in the sub-Antarctic rainforests of central and southern Chile. According to the literature (Ref. 2 and references therein) and as observed by a number of scientists frequently traveling in South America, this nut is often referred to as a substitute or replacement for *Macadamia* nuts and oil (Weigend, M., private communication). The two nuts are often compared and claimed to be "good sources of omega-6 FA," which both definitely are not. Numerous recommendations can be found for testing *Gevuina* as a new crop, a kind of "hardy *Macadamia,*" in temperate zones as far north as Vancouver Island, British Columbia. Apparently, an old *Gevuina* tree still exists in a Washington state nursery. Some health claims also can be found for *Gevuina* nuts and oil, which have been consumed by local populations in South America for centuries with no known ill effects (the name is derived from the Mapuche Indian word *guevín*). Although this local crop is presumably safe for human consumption, it should not be compared to *Macadamia* or even the European hazelnut (*Corylus*).

Gevuina seeds produce an oil that is totally different from other known edible oils. In fact, since at least 1965 [see references in the Seed Oil FA (SOFA) database (4,5)] it has been known that a major FA in this oil is 16:1Δ11*c*, also known as 16:1n-5, which typically constitutes about 25% of the total FA (4). There is a significant difference between *Gevuina* oil and traditional hazelnut oils (*Corylus avellana, C. colurna*), and *Gevuina* oil is also quite different from *Macadamia* oil (4). *Gevuina* seed oil is a typical n-5 oil or omega-5 oil, belonging in the same group as the seed oils from the much larger genus *Grevillea* (6) and a number of other Proteaceae species (7). These are distinct because they contain additional elongases, leading to FA chain lengths of 26 and above and—most notably—a range of n-5 monoene FA in their seeds. There could, for example, be a highly active n-5-desaturase in *Gevuina* (and *Grevillea*) seeds that is capable of transforming a range of saturated FA into the corresponding n-5 monoenes, regardless of chain length. Alternatively, a sequence of repeated chain-elongations could occur, leading to FA beyond the usual C_{18} chain length but starting already from an n-5 monoene primer. This should be investigated further, since it may be of considerable interest to researchers working on the production of "tailor-made" fats as renewable resources (8).

Grevillea spp. are typically grown as ornamental plants that do not produce edible nuts. They are cited here only for comparison purposes and as illustration. *Grevillea* spp. are the most typical representatives of n-5 oils known in the plant kingdom (4–7). The rare FA 16:1n-5 also was recently discovered in several species of the genus *Androsace*, a member of the Primulaceae, where it occurs at rather high levels in *A. lactea* (9). A few major occurrences of this unusual FA are shown in Table 1 (data taken from the SOFA database; see Ref. 4).

The main difference between *Gevuina* and *Macadamia,* as well as other edible oils, is in the total level of n-5 (omega-5) FA. No less than 51.2% of n-5 FA is found in *Gevuina* oil but only 0.3% in *Macadamia* seed oil, and this percentage is close to zero in all other edible oils (4). Another major difference is in the total level of long-chain FA (C_{20} and longer, 26.5%), which is much higher in *Gevuina* than in most other edible oils (4). For example, in *Macadamia* oil only 6.9% of the FA are $>C_{20}$ chain length.

Some n-7 FA such as *cis*-vaccenic acid (18:1Δ11*c* or 18:1n-7), present at low levels in most oils but at high levels in very few unusual edible oils, and palmitoleic acid (16:1Δ9c or 16:1n-7), a major FA in *Macadamia* oil, are generally considered safe for human consumption. But little is known about the biochemistry and catabolism of high levels of n-5 FA, particularly long-chain ones. Theoretically, at least, some interference could occur, e.g., by competitive inhibition or similar effects, with enzymes of lipid metabolism when large quantities of n-5 FA are consumed. Research publications dealing with this topic are extremely limited, if available at all; hence, research in this direction should be recommended.

Attention should be drawn to the rather unusual individual FA composition found in *Gevuina* (5), and a word of caution may be in order. Two recent papers in *JAOCS* (2,3) prompted me to report our own findings on *Gevuina*, *Grevillea,* and *Macadamia* oils in somewhat more detail and to discuss these in comparison with the European hazelnut (*Corylus*), although a more comprehensive report on Proteaceae oils and n-5 oils is in preparation (Aitzetmuller, K., unpublished data).

TABLE 1
Selected Major Occurrences of the Unusual FA 16:1Δ11*c*[a]

Plant species	Percentage of 16:1Δ11*c*
Kermadecia sinuata	40.3
K. sinuata	40.2
Orites diversifolia	35.6
O. revoluta	35.6
Ziziphus jujuba var. *inermis*	33.3
Hicksbeachia pinnatifolia	28.5
H. pinnatifolia	26.7
Gevuina avellana	25.4
G. avellana	24.0
G. avellana	22.0
Grevillea decora	21.4
Cardwellia sublimis	17.0
Grevillea robusta	13.3
O. diversifolia	12.5
Hakea salicifolia	11.3
G. robusta	10.7
Androsace lactea	7.2

[a]As found in the published literature. This acid is also known as 16:1n-5. Data are taken from the Seed Oil FA (SOFA) database (4). See this database for the original references.

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It also should be mentioned briefly that the clusters of n-5 seed oils observed within the Proteaceae family are not always compatible with current botanical opinions on the subdivision of this plant family (4,7), so their chemotaxonomic implications need to be discussed further.

Figure 1 shows standardized SOFA "fingerprints" (10) of one sample each of *Gevuina* and *Grevillea* oils, two of the most prominent n-5 oils known in the plant kingdom (other species are listed in Table 1). (For an explanation of the "Δ-notations" used here and in the tables, see the SOFA database, Ref. 5). Figure 2 shows standardized SOFA fingerprints of *Macadamia* and of a tree hazelnut (*C. colurna*) oil. These types of GLC fingerprints are regularly used in this laboratory to characterize seed oils (and "unknown" oils) and are obtained using a Silar-5CP column (Chrompack, Middelburg, The Netherlands) under standardized conditions (10). Deviations from the regular GLC pattern of "usual" FA in "usual" edible oils such as *Corylus* are easily seen under these conditions (note how much both the *Gevuina* and *Macadamia* SOFA fingerprints deviate from that of *Corylus* in Fig. 2). In our view, this GLC column is also the best for detecting unusual FA and for separating positional and other isomers of FA. (In highly complex oils, this column will show the largest number of separated peaks, whereas other columns will usually show fewer peaks because of more overlaps.) We always use a Silar-5CP column for the initial analysis of an unknown seed oil, because this is the easiest way not only to detect the presence of unusual FA but also to tentatively identify the unknown acids as far as possible from their ECL value or peak recognition values (PRV) (Ref. 9, Table 2). A large collection of GLC PRV data (obtained on a Silar-5CP column from about 250 different FA occurring in various seeds of the plant kingdom), is available in this laboratory and will be published at a later date (Aitzetmuller, K., unpublished data).

The FA compositions of *Gevuina*, *Macadamia*, *Grevillea,* and *Corylus* seed oils, as determined in this laboratory, are shown in Table 2. As one can clearly see from the data in this table, a number of recent claims regarding omega-6 and/or omega-3 FA—such as "Macadamia nut oil has the most balanced ratio of omega-3 to omega-6 FA of all culinary oils" (Macadamia Oils of Australia, www.macadamiaoils.com)—are questionable at best.

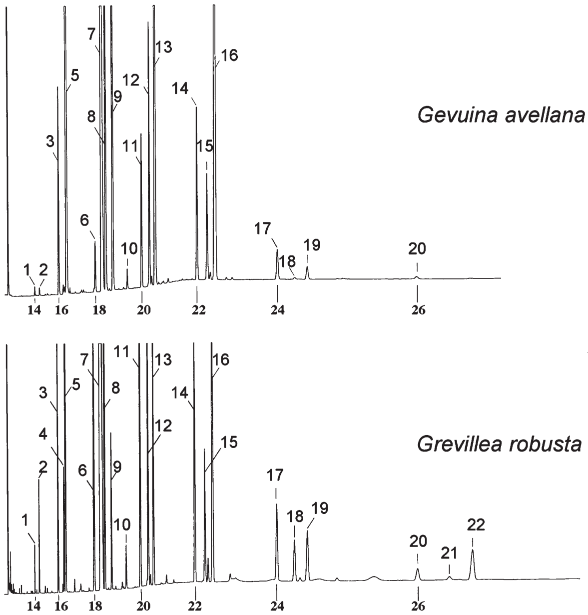

FIG. 1. Standardized seed oil FA "fingerprints" (10) of *Gevuina* and *Grevillea* seed oils on a Silar-5CP GLC column (Chrompack, Middelburg, The Netherlands). Of the many FA peaks shown, the peak numbers 2, 5, 8, 13, 16, 19, and 22 are "n-5 acids" (omega-5 monoenes). *x* axis, peak recognition values; *y* axis, recorder response. Peak numbers [see the Seed Oil FA (SOFA) database (5) for an explanation of the Δ-notations]: 1 = 14:0; 2 = 14:1Δ9*c* (14:1n-5); 3 = 16:0; 4 = 16:1Δ9c (16:1n-7); 5 = 16:1Δ11*c* (16:1n-5); 6 = 18:0; 7 = 18:1Δ9c (18:1n-9); 8 = 18:1Δ13*c* (18:1n-5); 9 = 18:2Δ9*c*,12*c* (18:2n-6); 10 = 18:3Δ9*c*,12*c*,15*c* (18:3n-3); 11 = 20:0; 12 = 20:1Δ11*c* (20:1n-9); 13 = 20:1Δ15*c* (20:1n-5); 14 = 22:0; 15 = 22:1Δ13*c* (22:1n-9); 16 = 22:1Δ17*c* (22:1n-5); 17 = 24:0; 18 = 24:1Δ15*c* (24:1n-9); 19 = 24:1Δ19*c* (24:1n-5); 20 = 26:0; 21 = 26:1Δ17*c* (26:1n-9); 22 = 26:1Δ21*c* (26:1n-5); 23 = 12:0; 24 = 20:1Δ13*c* (20:1n-7); 25 = 22:1Δ15*c* (22:1n-7).

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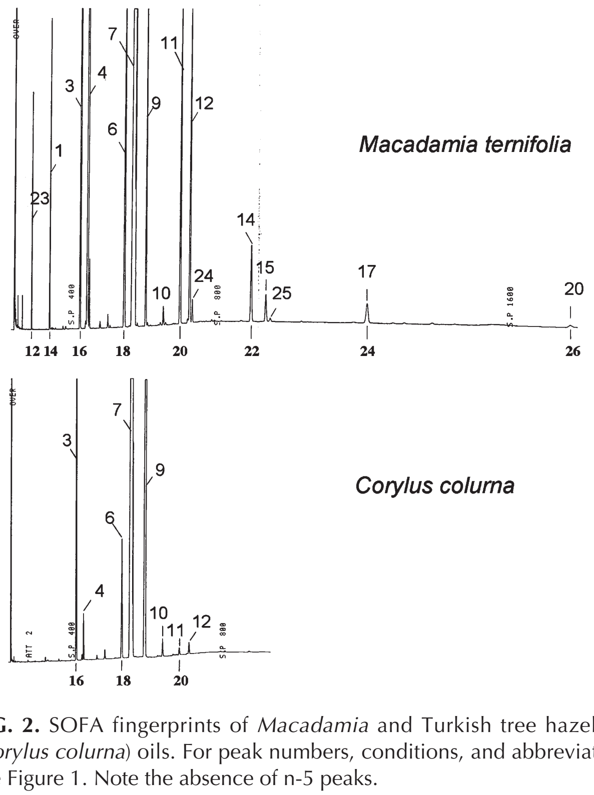

FIG. 2. SOFA fingerprints of *Macadamia* and Turkish tree hazelnut (*Corylus colurna*) oils. For peak numbers, conditions, and abbreviation see Figure 1. Note the absence of n-5 peaks.

TABLE 2
FA Composition of *Gevuina* and Other Related Seed Oils[a]

Peak no.	PRV[b]	Δ-Notation[c]	Family shorthand	*Gevuina avellana*	*Macadamia ternifolia*[d]	*Corylus avellana*	*Corylus colurna*	*Grevillea robusta* (1996)[e]	*Grevillea robusta* (2000)[e]
23	**12.00**	**12:0**			0.5			Tr	Tr
1	**14.00**	**14:0**		0.1	1.0		Tr	0.1	0.2
2	14.39	14:1Δ9*c*	14:1**n-5**	**Tr**				**0.4**	**0.4**
3	**16.00**	**16:0**		1.6	8.2	4.9	5.3	2.6	2.6
4	16.30	16:1Δ9*c*	16:1n-7	0.1	19.9	0.2	0.4	0.6	0.6
5	16.42	16:1Δ11*c*	16:1**n-5**	**24.2**	**0.3**			**10.7**	**10.8**
6	**18.00**	**18:0**		0.5	2.8	2.2	1.5	3.2	3.3
7	18.29	18:1Δ9*c*	18:1n-9	29.3	54.0	80.3	68.1	48.9	49.1
	18.35	18:1Δ11*c*	18:1n-7	ND	3.6		1.6	1.1	1.1
8	18.47	18:1Δ13*c*	18:1**n-5**	**8.4**	**Tr**			**6.0**	**6.1**
9	18.77	18:2Δ9*c*,12*c*	18:2n-6	8.8	2.3	10.8	22.4	1.0	1.0
10	19.39	18:3Δ9*c*,12*c*,15*c*	18:3n-3	0.2	0.1	0.3	0.2	0.3	0.3
11	**20.00**	**20:0**		1.4	2.5	0.3	0.1	3.4	3.2
12	20.28	20:1Δ11*c*	20:1n-9	2.4	2.7	0.2	0.1	2.7	2.7
24	20.36	20:1Δ13*c*	20:1n-7	0.1	0.2			0.1	0.1
13	20.48	20:1Δ15*c*	20:1**n-5**	**8.5**				**3.0**	**3.0**
14	**22.00**	**22:0**		1.9	0.8			3.0	2.7
15	22.25	22:1Δ13*c*	22:1n-9	1.3	0.3	0.1		1.5	1.4
25	22.32	22:1Δ15*c*	22:1n-7	0.1				0.3	0.3
16	22.45	22:1Δ17*c*	22:1**n-5**	**9.8**				**4.6**	**4.5**
17	**24.00**	**24:0**		0.6	0.4			1.5	1.3
18	24.25	24:1Δ15*c*	24:1n-9	Tr				0.8	0.8
19	24.43	24:1Δ19*c*	24:1**n-5**	**0.3**				**1.0**	**1.0**
20	**26.00**	**26:0**		0.1				0.5	0.4
21	26.25	26:1Δ17*c*	26:1n-9					0.1	0.1
22	26.42	26:1Δ21*c*	26:1**n-5**					**1.1**	**1.1**
—	28.44	28:1Δ23*c*	28:1**n-5**					**0.5**	**0.5**
—	—	**Total n-5 FA**	**n-5**	**51.2**	**0.3**	**—**	**—**	**27.3**	**27.4**
—	—	**Total FA ≥C_{20}**	**≥C_{20}**	26.5	6.9	0.6	0.2	24.1	23.1

[a]FAME were analyzed by capillary GLC on a Silar-5CP column (Chrompack, Middelburg, The Netherlands) using the standardized fingerprint technique (10) described previously. Data are expressed in area% (GLC) of total FA. Tr, trace; ND, not detected; see Table 1 for other abbreviation. Boldface type in columns 4–6, 9, and 10 indicates n-5 FA.
[b]PRV, peak recognition values on Silar-5CP. These are similar to ECL but calculated from a standardized *temperature-gradient* Silar-5CP GLC column by linear interpolation between the peaks of *even-numbered* saturated FA (9) (indicated in bold in columns 2 and 3). The PRV data were calculated and collected over a period of about 12 yr and are very stable, even during progressive column aging, which leads to reduced overall retention times.
[c]Δ-Notations are used in SOFA (5) as computer-readable character strings for the unambiguous identification of FA and their partial structures.
[d]The planted crop varieties should perhaps more correctly be labeled *M. ternifolia* var. *integrifolia*, or *M. integrifolia*. The nuts of the original Queensland wild species *M. ternifolia* are said to be inedible because they contain cyanogenic compounds (see, for example, www.brisrain.webcentral.com.au/database/Macad_ternifolia.htm).
[e]Analyzed in 1996 and reanalyzed in 2000.

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