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The contents of lignans in commercial sesame oils of Taiwan and their changes during heating

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Abstract

Sesame lignans have multiple functions and were recently reported to have potential as sources of phytoestrogens. Sesame oils used in Taiwan are expelled from roasted sesame seeds with dark colour and strong flavour. This study analyzed lignan contents of 14 brands of sesame oils, and found their mean of total lignans to be 11.5 mg/g; 82% and 15% of the lignans were sesamin, and sesamolin, respectively. Sesamol contents were relatively higher in those with darker colour. In use as a cooking oil, heating at 180 °C for 4 min did not change the content of lignans, but the level of sesamol increased after heating at 180 °C for 20 min. Heating at 200 °C for 20 min caused a significant loss of sesamolin and sesamol. From our calculation, ingestion of 10 g of sesame oil is adequate to provide the level of lignans that might benefit cardiovascular health, as found by other studies. Cooking at temperatures above 200 °C will cause loss of some lignans, but sesamin, a source of phytoestrogen, is relatively heat-stable.

Keywords: Sesame oil; Sesamin; Sesamolin; Sesamol; Heating

1. Introduction

Sesame (*Sesamum indicum* L.) seeds have long been considered a very popular health food in Asian countries. Sesame oil is commonly used as a cooking oil in Taiwan and women in the first month after delivery are highly recommended to eat chicken cooked with sesame oil as a traditional medicinal food. Sesame oil contains a class of unusual compounds known as lignans, comprised of sesamin, sesamolin, and a small amount of sesamol (Namiki, 1995). They have multiple physiological functions, such as decreasing blood lipids (Hirata et al., 1996) and arachidonic acid levels (Shimizu et al., 1991), increasing antioxidative ability (Hemalatha, Raghunath, & Ghafoorunissa, 2004) and γ-tocopherol bioavailability (Lemcke-Norojarvi et al., 2001), and providing anti-inflammatory function (Hsu et al., 2005; Utsunomiya, Chavali, Zhong, & Forse, 2000) and estrogenic activity (Coulman, Liu, Hum, Michaelides, & Thompson, 2005; Peñalvo, Heinonen, Aura, & Adlercreutz, 2005; Wu, Kang, Wang, Jou, & Wang, 2006). Sesame oil used in Taiwan is expressed from roasted sesame seed, with dark colour and very strong flavour, which differs from that from unroasted sesame seed, used in other countries (Namiki, 1995). This study aimed to determine the concentrations of lignans in commercial sesame oils manufactured in Taiwan, and their changes during the heating process used in general Chinese cuisine, in order to estimate the amount of lignans ingested and how much sesame oil is required to achieve the amount of lignans that might benefit health.

2. Materials and methods

2.1. Samples

Fifteen different brands of sesame oil and three brands of blend sesame oil were purchased from supermarkets in

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Taipei, Taiwan. Most of the sesame seeds in Taiwan were imported from Thailand, Burma, India and China. To imitate general Chinese cooking, sesame oils were heated at 180 °C for 4, or 20 min, or at 200 °C for 20 min. The oils were put into an oven that had been preheated to the proper temperatures.

2.2. Analysis

Sesamol was obtained from Sigma Chemical Co. (St. Louis, MO, USA). Sesamin and sesamolin were kindly provided by Professor Lucy Sun Hwang (National Taiwan University, Taipei, Taiwan), who prepared and purified sesame lignans in her laboratory (Shyu & Hwang, 2002). Sesame lignans were analyzed as described by Shahidi, Amarowicz, Abou-Gharbia, and Shehata (1997), using HPLC equipped with a Shim-pack CLC-ODS column (25 cm × 4.6 mm i.d., 5 μm film; Merck, Darmstadt, Germany). The mobile phase was a mixture of methanol-deionized water (70:30, v/v) at a flow rate of 0.8 ml/min. Absorption at 290 nm was monitored. Twenty microlitre aliquots of oils, dissolved in chloroform (0.5 mg/ml), were used for analysis. The retention times for sesamol, sesamin, and sesamolin were 4.5, 15.8 and 21.4 min, respectively.

The relationships between lignan contents were assessed using two-tailed Pearson's bivariate correlation. Changes in lignan composition after heating of sesame oils were analyzed by a paired two-tailed *t*-test. Results were considered significant at $P < 0.05$. All analyses were conducted using SPSS 11.5.

3. Results and discussion

3.1. Concentrations of lignans in commercial sesame oils (Table 1)

Among the 15 brands of sesame oil examined, one had a much lower concentration of lignans (total, 4.5 mg/g; sesamin, 4.0 mg/g; sesamolin, 0.3 mg/g; sesamol, 0.2 mg/g) than the others. It was probably not a pure sesame oil, so its data were excluded from analysis. The mean content of total sesame lignans in 14 brands of sesame oil was 11.5 mg/g (Table 1) similar to that classified as a medium lignan content sesame oil (10–20 mg/g) by Hemalatha and Ghafoorunissa (2004) from India and that from Japan (Sugano & Akimoto, 1993), but other reports from Japan (Namiki, 1995) and Korea (Kim & Choe, 2005) showed somewhat lower levels (8–7 mg/g). It seems that most of Taiwanese commercial sesame oils were from species of high sesamin contents because 82% of the total lignans was sesamin and 15% was sesamolin. The amounts of these two were positively correlated with the amount of total lignans ($r = 0.999$, $P < 0.0001$; $r = 0.763$, $P = 0.001$, respectively). Sesamol was the lowest among the sesame lignans and its amount was negatively correlated with sesamolin ($r = -0.572$, $P = 0.033$), consistent with the fact that it was produced from the degradation of sesamolin during the roasting process of sesame seeds (Yoshida & Takagi, 1997). Our mean sesamolin content (1.7 mg/g) was lower than that of Japanese sesame oil (3 mg/g), and the level of sesamol was 10-fold higher than that reported

Table 1
The contents of lignans in 14 brands of commercial sesame oils and three brands of blend sesame oils made in Taiwan

	Sesamin (mg/g)	Sesamolin (mg/g)	Sesamol (mg/g)	Total (mg/g)	Sesamol + sesamolin (mg/g)
Taiwanese sesame oil ($n = 14$)					
1	13.77	3.37	0.16	17.30	3.53
2	11.97	2.33	0.32	14.62	2.65
3	12.21	1.18	0.48	13.81	1.59
4	11.13	1.66	0.37	13.16	2.03
5	9.57	2.74	0.22	12.53	2.96
6	10.46	1.65	0.26	12.37	1.91
7	9.28	2.60	0.19	12.07	2.79
8	9.18	1.57	0.41	11.16	1.98
9	9.07	1.43	0.31	10.81	1.74
10	8.77	1.06	0.45	10.29	1.51
11	8.08	1.80	0.17	10.05	1.97
12	6.63	1.26	0.19	8.08	1.45
13	6.43	0.84	0.45	7.73	1.29
14	6.05	0.83	0.23	7.11	1.06
Mean ± SD	9.47 ± 2.28	1.74 ± 0.76	0.30 ± 0.11	11.51 ± 2.81	2.03 ± 0.71
Japanese sesame oil[a] ($n = 14$)					
Mean ± SD	4.91 ± 1.99	3.00 ± 1.14	0.03 ± 0.03	8.02 ± 2.93	3.14 ± 1.20
Taiwanese blend sesame oils ($n = 3$)					
1	3.61	0.84	0.08	4.53	0.92
2	5.10	1.30	0.07	6.48	1.38
3	1.36	0.34	0.05	1.76	0.40
Mean ± SD	3.36 ± 1.88	0.83 ± 0.48	0.07 ± 0.02	4.26 ± 2.37	0.90 ± 0.49

Value is an average of duplicate analysis.
[a] Data are from Namiki (1995).

Table 2
Changes in the concentrations of sesame lignans after sesame oils were heated

	Sesamin (mg/g)	Sesamolin (mg/g)	Sesamol (mg/g)	Total (mg/g)	Sesamol + sesamolin (mg/g)
n = *6*					
Original	10.39 ± 2.03	1.98 ± 0.63	0.29 ± 0.14	12.64 ± 2.03	2.25 ± 0.57
180 °C, 4 min	10.92 ± 1.67	2.11 ± 0.90	0.29 ± 0.11	13.33 ± 2.17	2.40 ± 0.86
200 °C, 20 min	9.91 ± 1.70	0[a]	0.10 ± 0.13	10.32 ± 1.83	0.10 ± 0.13[a]
n = *8*					
Original	8.38 ± 1.60	2.44 ± 1.04	0.15 ± 0.07	10.96 ± 2.28	2.58 ± 1.03
180 °C, 20 min	9.06 ± 1.46	1.39 ± 1.35[a]	0.51 ± 0.31[a]	10.96 ± 2.20	1.90 ± 1.17

Values are means ± SD.
[a] Significantly different from that of original sesame oil by paired *t*-test.

in Japanese oils (Namiki, 1995). The results were expected because Japanese sesame seed was not roasted prior to expelling the oil. There are two basic strains of sesame seed, black and white. Sample number 13, with dark colour and high content of sesamol, was expelled from white sesame seed. We observed that samples numbered 3, 4, 8, 9 and 13 were apparently darker and had higher contents of sesamol, so we postulated that the colour of the oils reflected the content of sesamol, regardless of the total amount of lignans or whether the oil was expelled from black or white sesame seeds. Lignan content in blend sesame oil, which is usually used in seasoning and manufactured by mixing with other vegetable oils, was half to one-third that of sesame oil (Table 1).

3.2. Changes in lignan composition after heating of sesame oils (Table 2)

After heating at 180 °C for 4 min, which imitates quick frying in Chinese cuisine, the contents of lignans did not change at all. On the other hand, after 20 min at 200 °C, sesamolin disappeared and sesamol did not have a parallel increase in any of the samples tested. Therefore, sesame oil had been over-heated at this condition. When sesame oil was heated at 180 °C for 20 min, the content of sesamol increased and sesamolin decreased. The sum of sesamol and sesamolin decreased slightly but not significantly. The content of sesamin changed little, under all heating conditions tested. Fukuda, Nagata, Osawa, and Namiki (1986) investigated the decomposition of sesamolin in a roasted sesame oil sample by more prolonged heating. They found sesamol level increased rapidly, reaching a maximum level after heating at 180 °C for 1 h or at 200 °C for 0.5 h and then gradually decreased to a level lower than the baseline value during 7 h of heating. Sesamolin in that oil completely disappeared after heating at 180 °C for 2 h or at 200 °C for 1 h, while sesamolin in our oils disappeared more quickly in 20 min at 200 °C.

Sesamol has strong anti-oxidative ability (Namiki, 1995) and a potential effect on fibrinolysis (Chen, Lee, Chang, & Tsai, 2005). If more sesamol is preferred, besides by increasing seed roasting temperature and time during processing, sesamol level in sesame oil could be further increased by heating the oil at 180 °C for 20 min. For providing anti-inflammatory function by inhibiting Δ5 desaturase, sesamin and sesamolin are needed (Shimizu et al., 1991); for increasing γ-tocopherol bioavailability, by inhibiting cytochrome 4504F2 (Sontag & Parker, 2002), or for providing phytoestrogen (Peñalvo et al., 2005), sesamin is needed; thus to preserve optimum functions of lignans, sesame oil is better cooked at temperature below 180 °C and in a short time.

3.3. The dose of sesame oil that provides lignans at a level that might benefit health

A clinical trial showed a decrease in plasma cholesterol in hypercholesterolemic subjects after ingesting 65 mg isolated sesamin daily for four weeks (Hirata et al., 1996). The amount consumed was approximately equivalent to consuming 7 g of sesame oil. Sesamin is so far the most potent food known to effectively improve γ-tocopherol bioavailability (Jiang, Christen, Shigenaga, & Ames, 2001). A trial in young women showed a 43% increase in serum γ-tocopherol level by ingesting 100 mg sesamin daily from sesame oil (Lemcke-Norojarvi et al., 2001). This amount of sesamin can be obtained from 10 g of sesame oil. The lowest dose of sesamin required to provide estrogenic activity for postmenopausal women has not been reported. Flaxseed is a well-known lignan-rich food and source of phytoestrogens, but its lignan content (3 mg/g) (Milder, Arts, van de Putte, Venema, & Hollman, 2005) is less. Moreover, its lignans are not contained in the oil fraction (Peñalvo et al., 2005). Therefore sesame oil is unique for its high content of lignans and, as a cooking oil, it can be easily incorporated into a normal diet at a level that might benefit health.

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