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Fatty Acids, Triacylglycerol and *Sn*-2 Fatty Acids Distributions Variations in Seed Oil from *Camellia* Cultivars

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Abstract: Camellia seed oil is widely used in the food, health, cosmetics and medicine industries in China. The present study aimed to investigate fatty acids, triacylglycerols (TGAs) and *sn*-2 fatty acids distributions variations in seed oil from 46 kinds of *Camellia* cultivars. The predominant fatty acids was oleic acid (18:1ω9) with 71.30% (average). The *sn*-2 position was mainly occupied by oleic acid, linoleic acid and palmitic acid. Fifteen TAGs species were found and the main TAGs were OOO + SLO, OOP and OOL+SLL. The trisaturated TAGs species were not detected. These results indicated significant changes in the profiles of fatty acids, *sn*-2 position fatty acids and TGAs, and in contents of these in seed oils from different *Camellia* cultivars ($P < 0.05$). Saturated fatty acids is not positively related to its distribution in *sn*-2 position. The data in present paper may be important as a reference for adulteration of camellia seed oil with other oils.

Keywords: Camellia Seed Oil, Fatty Acids, Triacylglycerols, *Sn*-2 Fatty Acids, *Camellia* Cultivars

1. Introduction

Camellia seed oil, extracted from *Camellia oleifera* Abel seed [1], is one of the famous four woody oil plants and has two thousand years history used extensively as edible oil and medicine in China [2], often titled "Eastern Olive Oil" due to high amounts of unsaturated fatty acids (UFAs, mainly oleic acid and linoleic acid) and bioactive compounds [3]. The UFAs content in the oil can reach as much as 90% and monounsaturated fatty acids (MUFAs) content is higher than that of olive oil [4]. Moreover, it is rich in vitamin E, squalene and flavonoids [5]. Now, camellia seed oil is recommended by the Food and Agriculture Organization of the United Nations as a high-quality, healthy vegetable oil.

The camellia seed oil is not only used extensively in China for cooking, but also has a long history of traditional cosmetic usage as a protectant to maintain the health of skin and hair [6, 7]. Apart from the traditional pharmacological effects, camellia seed oil may also act as a prophylactic agent to prevent free radical related diseases [8], a medicine for stomach ache and burns [9], antimicrobial and antiviral [10], protecting the liver against CCl4-induced oxidative damage [11], lowering blood pressure, cholesterol and triglycerides [12], and resistance to oxidative stress [13]. All above various biological activities of camellia seed oil may be attributed to many natural bioactives, such as polyphenols, saponin and squalene [5]. So, camellia seed oil is often the target for adulteration or mislabeling due to its high price with high nutritional and medical values [14]. In addition, camellia seed oil is a suitable feedstock for non-food applications, including surfactants, biodiesel, lubricants, and biopolymers [15].

Hunan Province is the main camellia seed oil producing area in China and its production accounts for more than 40% of China. At present, more than hundred kinds of cultivars, belonging to excellent clones cultivars (ECC) and excellent farm cultivars (EFC), has been planted in Hunan province.

However, above all *Camellia* cultivars were bred using some good economic traits as only criterion, such as high oil content, thin shell, more seeds, precocious, high fruit rate and so on and little attention was paid to oil characteristics, including fatty acids profile, unsaturated fatty acids, *sn*-2 fatty acid, triacylglycerols (TGAs) composition and molecular species, and even bioactive compounds. There are some reports about the fatty acids profiles of oil obtained from different *Camellia* species [1, 16, 17] and cultivars [18], but relatively information on the fatty acids profiles, *sn*-2 fatty acids distribution and TGAs of the oils from *Camellia oleifera* cultivars is very few, especially for *Camellia* cultivars planted in Hunan province. Therefore, the objectives of this research were to elucidate the composition of oils from seeds of 46 selected *Camellia* cultivars collected from Hunan province. The information obtained from this study can be used for further bud grafting or seed propagation, specifically for the production of fatty acids, are of interest. This is the first time that the lipid constituents of selected camellia seeds from different cultivars in Hunan province have been described.

2. Materials and Methods

2.1. Materials

46 of camellia seed samples from different cultivars, including 17 of EFC and 29 of ECC, in Hunan province were harvested at commercial maturity stage by National Camellia Engineering Technology Research Center in 2014(shown in Table 1). Camellia seed samples were collected from at least four different trees in each cultivars and pooled. The samples were transported in the boxes within 10 h. Stones from the camellia fruits were removed, and individual stones were hammered in order to obtain the seeds. The 1kg seeds were dried until about 3.5% moisture at open air conditions and were placed into polyethylene bags and stored at 4°C until further analysis. All analyses were performed at least in duplicate.

Table 1. *Description of Samples information.*

No	Cultivars	Abbreviation	Validated/Identificated No	Notation
1	Xianglin 1	XL1	国 S-SC-CO-13-2006	
2	Xianglin 5	XL5	国 R-SC-CO-006-2006	
3	Xianglin 81	XL81	湘 S9664-CO2	
4	Xianglin 70	XL70	湘 S9661-CO2	
5	Xianglin 97	XL97	国 S-SC-CO-019-2009	
6	Xianglin 27	XL27	国 S-SC-CO-013-2009	
7	Xianglin 124	XL124	湘 S-SC-CO-057-2010	
8	Xianglin 117	XL117	湘 S-SC-CO-055-2010	
9	Xianglin 92	XL92	湘 S9641-CO2	
10	Xianglin 63	XL63	国 S-SC-CO-034-2011	
11	Xianglin 67	XL67	国 S-SC-CO-015-2009	
12	Xianglin 69	XL69	湘 S9660-CO2	
13	Xianglin 78	XL78	国 S-SC-CO-035-2011	
14	Xianglin 121	XL121	湘 S-SC-CO-056-2010	Excellent clones cultivars (ECC)
15	Xianglin 97	XL97	国 S-SC-CO-019-2009	
16	Xianglin 131	XL131	湘 S-SC-CO-058-2010	
17	XLJ2	XLJ2	湘 S0706—Co1a	
18	Huashuo	HS	国 S-SC-CO-011-2009	
19	Huajin	HJ	国 S-SC-CO-010-2009	
20	Huaxin	HX	国 S-SC-CO-009-2009	
21	Xianglin 106	XL106	湘 S-SC-CO-054-2010	
22	Xianglin 210	XL1210	国 S-SC-CO-015-2006	
23	Liuyang youcha hybridization seed	LYHS	湘 S-CSO(1)-CO-059-2010	
24	Huahong	HH	湘 R-SF-CO-006-2015	
25	XLJ14	XLJ14	国 R-SC-CO-005-2006	
26	Xianglin 104	XL104	国 S-SC-CO-14-2006	
27	Changde Tiecheng 1	CDTC1	湘 S0801-Co2	
28	Hengdong Datao 2	HDDT 2	湘 S-SC-CO-003-2012	
29	Hengdong Datao 39	HDDT39	湘 S-SC-CO-004-2012	
30	Hengdong 15	HD15		
31	Hengdong 8	HD8		
32	Zhushang Honghua	ZSHH		
33	Jiangtuo Huangqiu	JTHQ		Excellent farm cultivars (EFC)
34	Yongxing Zhongbaohongqiu	YXZBHQ		
35	Balingzi	BLZ		
36	Xianglin 34	XL34		
37	Xianglin 169	XL169		
38	Changsha 14	CS14		

No	Cultivars	Abbreviation	Validated/Identificated No	Notation
39	Dezi 1	DZ1		
40	Ningyuan 7802	NY7802		
41	Ningyuan 7810	NY7810		
42	Wushicha 26	WSC26		
43	Youxian 1	YX1		
44	Youxian 8	YX8		
45	Youxian 9	YX9		
46	Youxian 10	YX10		

Fatty acid methyl esters (FAMEs) mixture (37 component FAMEs mix, 10 mg/ mL of the FAMEs reference standard mix in methylene chloride, catalog no. 47885-U) were purchased from Supelco (Bellefonte, PA). TGAs mixture were purchased from Shanghai ZZBio Co., Ltd (China).Thin layer chromatography (TLC) plates (GF254) pursed from Qingdao Haiyang Chemical Co., Ltd (China). Porcine pancreatic lipase (EC 3.1.1.3, type II, crude) were purchased from Sigma (St. Louis, MO). All other chemicals and reagents were analytical or chromatographic grades and purchased from Sinopharm Chemical Regent co., Ltd (China).

2.2. Oil-Producing Processing

Oil was extracted from camellia seeds (1 kg) by cold pressing using a lab-type oil press (KOMAT CA59G, Germany), after filtrated, oil samples was kept in glass containers under at 4℃ until used.

2.3. Fatty Acid Analysis

According to the ISO method 12966-2 [19], FAMEs of the extracted oils were prepared with minor modified as following: methanolic potassium hydroxide (0.2M) was added to 0.1 g oil in 2mL *n*-heptane. The mixture was shaken vigorously and allowed to stand and separate. An aliquot (1 mL) of the heptane phase was removed and stored until analyzed. Fatty acid compositions were determined using a gas chromatograph (Shimadzu GC-2010, Japan) equipped with a flame ionization detector and a SP-2340 capillary column (60m×0.25mm, i.d.×0.25mm film thickness). The oven temperature was set at 170°C and was held there for 10 min. Then, it was increased to 180°C at 10°C/min, held for 10 min and increased again to 220°C at 4°C /min. Injector temperature was set at 245°C with a split ratio of 1:50 and detector temperature was set at 280°C. Helium was used as the carrier gas at a flow rate of 1.5 mL/min. The FAMEs were identified by comparing their retention times with those of standard samples. The quantitative analysis of fatty acids in camellia seed was used pentacdecanoic acid as internal standard.

2.4. Sn-2 Fatty Acid Analysis

Sn-2 fatty acids analysis was operated according to the AOCS Official Method Ch 3-91 [20]. This method entails several steps: selective hydrolysis of the 1,3-position of fatty acids in the camellia seed oils with pancreatic lipase; separation of the obtained monoacylglycerols (MAGs) by TLC, using silica gel 60 plates and a developing solvent mixture of *n*-hexane, ether, and acetic acid in the proportions 70/30/1 (v/v/v); identification of the MAGs band (R_f=0.24) under UV light; and, finally, analysis of the MAGs by GC following conversion of the MAGs to methyl esters as described in the section fatty acid analysis. *sn*-2 fatty acid analysis was performed in duplicate for single samples of each variety, and average values were reported.

2.5. TGAs Analysis

TGAs compositions of camellia seed oils were determined by reversed-phase high performance liquid chromatography (RP-HPLC) using the AOCS Official Method Ce 5b-89 [21]. Briefly, 0.1 g oil was dissolved in 2 mL of acetone and filtered through a 0.45 µm pore size syringe filter (Millipore, Bedford, MA). Twenty microliters of filtered oil was directly injected into the HPLC system (Shimadzu LC-20A, Japan), integrated with an auto sampler (SIL-20A), temperature control for the column (CTO-20A), a degasser system (DGU-20A), and a binary high pressure gradient pump (LC-20A) (Shimadzu Excellence in Science, Japan). The effluent was monitored with a 2000ES Evaporative light scattering detector (Alltech, Inc., USA), with the following settings: evaporator temperature 40°C, air pressure 3.5 bar and photomultiplier sensitivity 6. The chromatograms were processed using a software package for system control and data management (LabSolutions CS, Shimadzu, Japan). The chromatographic separation of the compounds was achieved with a ZORBAX SB-C18 column (250 mm×4.6 mm; 5 µm; Agilent, USA) operated at 25°C. A gradient elution solvent system consisting of isopropyl alcohol (A) and acetonitrile (B) was used at a flow rate of 1.2 mL/min as following: 52% of B for 1-15 min, 64% of B for 15-60 min and then 52% of B for 60-85 min. Peaks were identified by taking into account the relative retention times of TGAs standards, and results were expressed as percentage of peak areas. TGAs determination were performed in duplicate for single samples of each variety, and average values were reported.

2.6. Statistics

The data were analyzed by analysis of variance (ANOVA) using SPSS version 20.0. (SPSS Inc., Chicago, IL). When significant (P < 0.05) differences were found among the seed oils extracted from different *Camellia* cultivars, a Duncan multiple range test was used for comparisons.

3. Results and Discussion

3.1. Fatty Acid Composition

Table 2. *Analysis of fatty acids profiles for 46 kinds of Camellia oil (g/100g).*

Cultivars	C16:0	C18:0	C18:1ω9	C18:2ω6	C18:3ω3	SFAs	UFAs	MUFAs	PUFAs
XL1	8.45±0.181^{p}	2.32±0.102^{l}	85.74±1.643^{l}	6.99±0.104^{j}	0.15±0.002^{c}	10.77±1.092^{kl}	92.88±4.145^{k}	85.74±2.343^{m}	7.14±0.102^{gh}
XL5	7.06±0.130^{g}	1.91±0.033j^{k}	76.06±1.738^{h}	5.12±0.042^{d}	0.10^{b}	8.97±0.264^{g}	81.29±4.803^{g}	76.06±2.438^{j}	5.23±0.142^{c}
XL81	7.04±0.101^{g}	2.14±0.012^{l}	70.89±1.821^{f}	6.02±0.093^{g}	0.15^{c}	9.18±0.308^{gh}	77.06±2.155^{e}	70.89±2.054^{g}	6.17±0.101^{e}
XL70	7.57±0.103^{k}	1.32±0.015^{f}	67.31±1.741^{d}	6.43±0.103^{i}	0.47^{hi}	8.88±0.609^{fg}	74.21±1.837^{d}	67.31±1.622^{f}	6.90±0.115^{g}
XL97	8.08±0.136^{m}	1.71±0.304^{i}	72.33±2.165^{fg}	6.05±0.106^{g}	0.13^{bc}	9.79±1.052^{ij}	78.51±2.047^{ef}	72.33±1.832^{h}	6.18±2.115^{e}
XL27	7.28±0.128^{hi}	1.70±0.209^{i}	73.53±2.187^{fg}	7.54±0.107^{l}	0.75^{m}	8.98±0.586^{g}	81.82±1.866^{g}	73.53±2.784i	8.29±0.182^{k}
XL124	6.95±0.110^{fg}	2.11±0.090^{l}	75.30±2.119^{g}	6.08±0.102^{gh}	0.14^{c}	9.06±0.819^{g}	81.53±2.021^{g}	75.30±1.720^{j}	6.23±0.102^{e}
XL117	7.77±0.106^{l}	1.66±0.002^{h}	79.00±2.054^{i}	6.83±0.107^{ij}	0.58±0.018^{k}	9.44±0.808^{h}	86.42±1.755^{i}	79.00±2.546^{k}	7.42±0.101^{h}
XL92	7.74±0.125^{kl}	0.93±0.002^{c}	67.09±1.728^{d}	8.26±0.230^{ml}	0.10^{b}	8.67±0.709^{f}	75.45±1.837^{de}	67.09±1.722^{f}	8.36±0.115^{kl}
XL63	8.25±0.102^{n}	1.36±0.028^{g}	72.23±1.329^{fg}	10.46±0.234^{q}	0.51±0.011^{i}	9.61±0.525^{i}	83.21±1.942^{h}	72.23±1.039^{h}	10.98±0.123^{p}
XL67	8.29±0.176^{n}	1.17±0.075^{e}	72.20±1.432^{fg}	8.17±0.136^{l}	0.19^{c}	9.46±1.252^{h}	80.57±2.047^{f}	72.21±1.8.32^{h}	8.36±0.215^{kl}
XL69	7.77±0.153^{l}	1.69±0.035^{i}	74.08±1.784^{g}	7.01±0.178^{j}	0.12^{bc}	9.46±0.786^{h}	81.21±1.676^{g}	74.08±1.784i	7.13±0.182^{gh}
XL78	8.66±0.121^{pq}	1.21±0.011^{f}	72.40±1.477^{fg}	9.64±0.122^{o}	0.58±0.003^{k}	9.88±1.31^{j}	82.61±1.983^{gh}	72.40±1.767 ^{h}	10.22±0.264^{o}
XL121	6.25±0.116^{bc}	2.22±0.011^{l}	74.82±2.198^{g}	4.69±0.020^{bc}	0.66±0.001^{l}	8.47±0.319^{df}	80.17±2.028^{f}	74.82±1.337^{ij}	5.35±0.108^{cd}
XL97	7.91±0.129^{m}	1.80±0.002^{j}	71.60±1.474^{f}	6.95±0.124^{ij}	0.37±0.005^{g}	9.70±0.545^{ij}	78.92±1.924^{ef}	71.60±1.856^{gh}	7.32±0.108^{h}
XL131	7.92±0.101^{m}	2.00±0.002^{l}	73.96±1.296^{g}	7.06±0.095^{j}	0.16^{c}	9.92±0.286^{k}	81.18±1.666^{g}	73.96±1.784^{i}	7.21±0.182^{gh}
XLJ2	7.00±0.108^{g}	1.60±0.006^{h}	68.66±1.452^{df}	6.18±0.101^{h}	0.25^{e}	8.60±0.312^{f}	75.09±1.366^{de}	68.66±1.725^{fg}	6.43±0.104^{f}
HS	9.28±0.105^{pq}	2.48±0.040^{lm}	90.03±2.506^{mn}	9.04±0.078^{n}	0.20^{d}	11.76±0.19^{n}	99.27±2.573^{m}	90.03±2.726^{n}	9.25±0.219^{m}
HJ	8.08±0.137^{m}	2.16±0.130^{l}	76.05±2.186^{h}	6.45±0.078^{i}	0.15^{c}	10.24±0.05^{kl}	82.64±2.352^{gh}	76.05±2.412^{j}	6.59±0.113^{f}
HX	8.13±0.119^{n}	0.89±0.030^{bc}	89.26±2.135^{m}	7.46±0.083^{kl}	0.24±0.002^{de}	9.01±0.419^{g}	96.96±2.271^{l}	89.26±3.020^{n}	7.70±0.102^{i}
XL106	7.36±0.101^{ij}	2.46±0.002^{lm}	72.06±1.814^{f}	5.47±0.106^{e}	0.09±0.012^{ab}	9.82±1.061^{j}	77.62±1.368^{e}	72.06±1.863^{h}	5.56±0.126^{d}
XL1210	8.75±0.135^{pq}	1.10±0.020^{e}	78.99±2.041^{i}	8.47±0.149^{m}	0.31±0.012^{f}	9.85±0.516^{j}	87.77±2.162i	78.99±2.402^{k}	8.78±0.162^{l}
LYHS	8.43±0.101^{p}	1.85±0.001^{j}	81.05±2.192^{k}	8.66±0.087^{m}	0.54±0.014^{j}	10.28±0.723^{kl}	90.25±2.134^{j}	81.05±2.096^{l}	9.20±0.310^{m}
HH	7.08±0.114^{gh}	1.62±0.011^{h}	74.92±1.649^{g}	6.64±0.120^{ij}	0.38^{g}	8.70±0.128 ^{f}	81.94±2.908^{g}	74.92±1.572^{ij}	7.02±0.437^{g}
XLJ14	8.13±0.105^{n}	0.87±0.001^{bc}	73.33±1.821^{fg}	6.84±0.074^{ij}	0.68^{l}	9.00±0.091^{g}	80.85±2.102^{f}	73.33±1.989^{i}	7.52±0.201^{hi}
XL104	7.55±0.104^{k}	2.03±0.006^{kl}	73.71±2.053^{fg}	5.96±0.028^{f}	0.68±0.008^{l}	9.58±1.650^{i}	80.35±2.373^{f}	73.71±1.793^{i}	6.64±0.283^{fg}
CDTC1	8.64±0.116^{pq}	2.49±0.0111^{m}	79.99±1.734^{ij}	8.59±0.120^{m}	0.59±0.011^{k}	11.14±1.009^{m}	89.16±2.128^{j}	79.99±2.307^{k}	9.18±0.108 ^{m}
HDDT 2	8.34±0.105^{pq}	1.95±0.006^{k}	77.82±1.866^{hi}	9.01±0.075^{n}	0.14^{c}	10.29±0.712^{kl}	86.97±2.136^{i}	77.82±1.825^{jk}	9.15±0.404 ^{m}
HDDT39	9.60±0.106^{p}	1.16±0.00^{4e}	65.77±1.285^{cd}	10.34±0.107^{p}	0.59±0.009^{k}	10.76±0.219^{l}	76.70±1.728^{e}	65.77±1.337^{d}	10.94±0.708 ^{p}
Average	8.26	2.08	74.72	7.61	0.38	14.61	78.64	74.72	8.04
HD15	9.02±0.117^{pq}	0.82±0.014^{bc}	68.20±1.924^{df}	9.36±0.821^{c}	0.36±0.017^{g}	9.84±0.220^{j}	77.92±2.732^{ef}	68.20±2.194^{fg}	9.72±0.138^{n}
HD8	6.75±0.126^{de}	1.13±0.002^{e}	63.13±1.904^{c}	7.32±0.125^{k}	0.50±0.008^{i}	7.89±0.417^{cd}	70.94±1.319^{c}	63.13±1.526^{cd}	7.81±0.112^{j}
ZSHH	6.86±0.109^{ef}	1.42±0.004^{g}	70.72±1.892^{f}	7.41±0.111^{k}	0.10^{b}	8.28±0.216^{d}	78.23±1.941^{ef}	70.72±1.135^{g}	7.51±0.306^{hi}
JTHQ	6.64±0.116^{cd}	1.39±0.010^{g}	69.84±1.547^{df}	5.01±0.118^{c}	0.51^{i}	8.03±0.323^{d}	75.36±1.858^{de}	69.84±1.736^{fg}	5.52±0.101^{d}
YXZBHQ	7.49±0.165^{ik}	1.51±0.012^{h}	71.70±1.832^{f}	7.64±0.146^{l}	0.55^{i}	9.01± 1.061^{g}	79.88±1.868^{f}	71.70±1.783^{gh}	8.19±0.226^{k}
BLZ	8.16±0.102^{n}	1.62±0.011^{h}	71.72±2.105^{f}	9.14±0.202^{o}	0.67±0.001^{l}	9.78±0.416^{ij}	81.53±2.415^{g}	71.72±1.375^{gh}	9.82±0.106^{n}
XL34	8.04±0.102^{m}	0.60±0.005^{a}	70.61±2.073^{f}	7.35±0.104^{k}	0.27^{e}	8.64±0.217^{f}	78.24±2.189^{ef}	70.61±1.806^{g}	7.62±0.412^{i}
XL169	7.64±0.103^{k}	1.21±0.040^{f}	66.81±1.304^{d}	7.77±0.107^{l}	0.11^{b}	8.86±0.716^{fg}	74.68±1.641^{d}	66.80±1.305^{df}	7.88±0.106^{j}
CS14	7.00±0.148^{fg}	1.40±0.102^{g}	64.66±1.543^{c}	5.99±0.052^{f}	0.35±0.004^{g}	8.40±0.500^{df}	71.00±1.782^{c}	64.66±1.762^{d}	6.34±0.100^{ef}
DZ1	6.90±0.173^{f}	0.72±0.001^{a}	57.30±2.149^{b}	2.13±0.014^{a}	0.05±0.002^{a}	7.62±0.373^{c}	59.48±1.066^{ab}	57.30±1.648^{b}	2.19±0.017^{a}
NY7802	5.59±0.189^{ab}	2.02±0.060^{kl}	62.60± 1.756^{c}	4.41±0.013^{b}	0.24^{de}	7.61±0.783^{c}	67.25±1.342^{b}	62.60±1.985^{c}	4.65±0.076^{b}
NY7810	7.08±0.106^{gh}	1.60±0.040^{h}	66.73±1.142^{d}	5.07±0.097^{c}	0.58±0.001^{k}	8.68±0.541^{f}	72.39±2.089^{cd}	66.73±1.076^{df}	5.65±0.106^{d}
WSC26	4.83±0.087^{a}	0.88±0.012^{bc}	48.61± 1.365^{a}	4.70±0.022^{bc}	0.13^{bc}	5.71±0.045^{a}	53.44±1.294^{a}	48.61±0.986^{a}	4.83±0.083^{b}
YX1	8.17±0.103^{n}	0.67±0.004^{a}	65.95±1.614^{cd}	7.05±0.073^{j}	0.43^{h}	8.84±0.045^{fg}	73.43±1.832^{cd}	65.95±1.812^{d}	7.48±0.113^{h}
YX8	9.57±0.104^{q}	0.95± 0.005^{c}	68.17±1.172^{df}	13.20±0.164^{r}	0.65±0.011^{l}	10.51±0.109^{l}	82.01±1.937^{gh}	68.17±1.522^{f}	13.84±0.515^{r}
YX9	8.93±0.112^{pq}	1.43±0.006^{g}	62.06±1.747^{c}	11.18±0.328^{q}	0.80±0.002^{n}	10.36±0.106^{l}	74.04±2.013^{d}	62.06±1.577^{c}	11.98±0.346^{q}
YX10	5.01±0.108^{a}	1.22±0.011^{f}	50.96±1.361^{a}	4.43±0.024^{b}	0.32±0.013^{fg}	6.24±0.039^{b}	55.71±1.297^{a}	50.97±2.061^{ab}	4.75±0.236^{b}
Average	7.27	1.21	64.69	7.01	0.39	8.49	71.46	64.37	6.99
Average	7.67	1.53	71.30	7.21	0.36	9.21	78.98	71.34	7.45
SD	1.034	0.517	8.020	2.012	0.221	1.152	9.001	8.107	1.923
CV	0.135	0.337	0.112	0.279	0.612	0.125	0.114	0.114	0.258
F(0.05)	13.303**	21.574**	8.542**	52.041**	42.129**	9.826**	8.500**	8.541**	54.129**

Each value is the mean (standard deviation of duplicate determinations. Means with different letters in the column for each camellia seed oil are significantly different (Duncan Test, $P < 0.05$).

The fatty acid profiles of camellia seed oils are shown in Table 2. Five fatty acids were identified, including oleic acid (18:1*ω*9, 71.30%), palmitic acid (16:0, 7.67%), linoleic acid (18:2*ω*6, 7.21%), stearic acid (18:0, 1.53%), linolenic acid (18:3*ω*3, 0.36%). Changes in the fatty acid composition of camellia seed oils were found to be significant ($P < 0.05$). Also, significant differences were found between the cultivars for total saturated fatty acids (SFAs), total MUFAs, and total polyunsaturated fatty acids (PUFAs). The total SFAs (5.71 ~11.76%) and PUFAs (2.19 ~11.98%) made up small proportions of the fatty acids in camellia seed oils, whereas MUFAs (71.37%) were higher (48.61 ~ 90.03%). Average UFAs (53.44 ~ 99.27%) accounted for 78.98% of the total fatty acids. The contents of palmitic and oleic acids presented in this study are similar with previously reported [22]. On the other hand, average contents for linoleic acid appeared with 7.21% (2.31~ 13.20%) in present paper, it is lower than that of reported for camellia seed oil [18]. When compared to other nut and vegetable oils, including almond (60.93%) [23], berry seed (12.4 ~ 22.9%) [24], apricot kernel oil (65.34%) [25, 26] and soybean (25%) [27], camellia seed oil contains the highest proportion of oleic acid.

Beside of linolenic acid (C18:3ω3), the fatty acids contents of EFC was all lower than that of ECC, the contents of oleic acid (C18:1ω9, average content with 64.37%) in EFC was lower than that of ECC (average value of 74.72%), the same information as MUFAs, UFAs and SFAs. Comparable to the reports [22], all results in present paper indicated it has not significant difference on fatty acids profile but on fatty acids composition between ECC and EFC, the fatty acid composition of camellia seed oil is significantly influenced by the type of cultivar. But due to different *Camellia* cultivars and different planting condition, palmitoleic acid (C16:1) and tetralosenoic acid (C24:1) [18] have not been detected in this work.

According the results, camellia seed oils is a good source of salad or frying oils due to its higher unsaturated oil content, including MUFAs (oleic acid) and ω-6 PUFAs (linoleic acid), which play a significant influence on lower total and LDL cholesterol [28, 29].

3.2. Sn-2 Fatty Acids

Table 3. *Analysis of sn-2 fatty acid profiles in 46 camellia cultivars.*

Cultivars	C16:0	C18:0	C18:1ω9	C18:2ω6	C18:3ω3	SFAs	UFAs	MUFAs	PUFAs
XL1	4.69±0.023^{c}	1.99±0.045^{ab}	66.94±1.923^{f}	20.00±0.977^{j}	6.39±0.008^{k}	6.68±0.065^{a}	93.33±2.304^{i}	66.94±0.894^{g}	26.39±1.451^{j}
XL5	2.37±0.019^{a}	3.78±0.014^{cd}	58.22±1.492^{d}	33.18±0.152^{m}	2.47±0.009^{h}	8.14±0.127^{b}	93.96±2.133^{i}	56.22±0.488^{de}	35.65±0.615^{l}
XL81	17.75±0.315^{m}	10.50±0.171^{i}	54.50±1.701^{cd}	15.50±0.271^{g}	1.75±0.035^{g}	28.25±0.354^{h}	71.75±1.635^{c}	54.50±0.707^{d}	17.25±0.354^{g}
XL70	15.07±0.152^{k}	10.28±0.154^{i}	54.68±1.223^{cd}	18.32±0.131^{hi}	1.67±0.008^{g}	25.34±0.028g^{h}	74.67±1.504^{d}	54.8±0.219^{d}	19.98±0.184^{gh}
XL97	13.90±0.176^{ij}	10.84±0.067^{ij}	50.48±2.740^{b}	12.44±0.692^{ef}	12.35±0.068^{m}	24.74±1.365^{g}	75.27±1.636^{d}	50.48±2.737^{b}	24.79±1.365^{i}
XL27	19.71±0.123^{o}	3.00±0.017^{c}	75.99±3.373^{hi}	0.88±0.003^{a}	0.43±0.002^{b}	22.71±0.163^{g}	77.30±1.216d^{e}	75.99±0.375^{i}	1.30±0.212^{a}
XL124	3.20±0.007^{b}	3.86±0.005^{cd}	76.47±0.579^{i}	13.36±0.873^{f}	3.12±0.015^{i}	7.06±0.009^{a}	92.95±3.326^{i}	76.47±0.235^{i}	16.48±1.256^{f}
XL117	19.59±0.016^{o}	16.93±0.098^{m}	54.29±1.119^{cd}	8.33±0.103^{c}	0.87±0.019^{e}	36.52±1.032^{j}	63.48±1.403^{a}	54.29±0.191^{d}	9.19±1.216^{c}
XL92	25.24±0.145^{q}	11.29±0.236^{j}	50.00±3.052^{b}	12.83±0.392^{ef}	0.66±0.004^{c}	36.52±0.382^{j}	63.48±1.393^{a}	50.00±3.048^{b}	13.48±2.437^{e}
XL63	18.93±0.188^{no}	16.66±0.959^{m}	54.27±1.174^{cd}	9.35±0.422^{d}	0.80±0.009^{de}	35.59±0.283^{j}	64.41±1.283^{a}	54.27±0.170^{d}	10.14±0.127^{cd}
XL67	5.68±0.036^{d}	2.06±0.00^{b}	68.96±1.497^{fg}	17.47±0.010^{h}	5.83±0.002^{j}	7.74±0.005^{a}	92.26±3.201^{i}	68.96±1.382^{gh}	23.30±1.234^{i}
XL69	10.51±0.125^{gh}	4.26±0.067^{d}	67.46±1.601^{f}	15.12±0.103^{g}	2.65±0.092^{hi}	14.77±0.346^{de}	85.23±2.385^{fg}	67.46±1.598^{g}	17.77±1.952^{g}
XL78	14.49±0.107^{j}	10.66±0.186^{ij}	71.40±1.214^{g}	2.42±0.071^{a}	0.54±0.004^{c}	25.15±0.785^{gh}	74.36±1.908^{d}	71.40±1.209^{hi}	2.95±0.131^{a}
XL121	12.19±1.173^{hi}	10.19±0.281^{i}	60.00±1.833^{de}	15.65±0.128^{g}	1.98±0.056^{gh}	22.38±0.559^{g}	77.63±1.562^{de}	60.00±1.831^{e}	17.63±1.273^{g}
XL97	16.29±0.109^{l}	11.72±0.063^{j}	59.85±0.922^{de}	11.31±0.213^{e}	0.82±0.0019^{de}	28.02±0.148^{h}	71.99±1.915^{c}	59.85±0.216^{e}	12.13±0.364^{d}
XL131	18.96±1.104^{no}	6.51±0.071^{f}	59.51±0.917^{de}	13.98±0.512^{f}	1.05±0.007^{f}	25.46±0.424^{gh}	74.54±1.452^{d}	59.51±0.170^{e}	15.03±0.594^{f}
XLJ2	8.14±0.033^{f}	5.59±0.032^{e}	68.95±0.924^{f}	16.68±0.062^{gh}	0.64±0.003^{c}	13.74±0.289^{d}	86.27±1.259^{g}	68.95±0.243^{gh}	17.32±0.055^{g}
HS	14.21±4.460^{j}	1.60±0.003^{a}	68.25±2.716^{f}	15.28±0.062^{g}	0.68±0.002^{cd}	15.80±2.956^{e}	84.20±1.964^{f}	68.25±2.765^{gh}	15.96±0.198^{f}
HJ	4.19±0.008^{c}	1.92±0.005^{ab}	71.70±1.784^{g}	17.18±0.023^{h}	5.00±0.001^{j}	6.11±0.005^{a}	93.88±2.034^{i}	71.70±2.378^{hi}	22.18±1.003^{h}
HX	9.86±0.302^{g}	3.32±0.013^{c}	75.82±1.657^{hi}	10.68±0.187^{de}	0.34±0.003^{ab}	13.18±1.435^{d}	86.83±1.483^{g}	75.82±6.569^{i}	11.02±1.148^{d}
XL106	9.90±0.106^{g}	4.15±0.107^{d}	63.36±1.446^{e}	19.87±0.653^{j}	2.72±0.084^{hi}	14.04±0.326^{de}	85.96±1.233^{fg}	63.36±0.444^{f}	22.59±0.763^{h}
XL1210	23.99±2.214^{pq}	11.96±1.024^{jk}	50.83±1.857^{b}	11.88±1.259^{e}	1.35±0.049^{fg}	35.95±1.188^{j}	64.05±1.260^{a}	50.83±1.874^{b}	13.23±3.076^{e}
LYHS	22.48±0.063^{p}	12.84±0.022^{k}	49.20±1.424^{ab}	13.77±0.018^{f}	1.73±0.006^{g}	35.31±0.283^{j}	64.70±1.293^{a}	49.20±0.424^{b}	15.50±0.141^{f}
HH	13.14±3.065^{i}	1.95±0.023^{ab}	68.82±2.193^{fg}	15.41±0.749^{g}	0.69±0.003^{cd}	15.09±2.428^{e}	84.91±2.043^{f}	68.82±2.191^{gh}	16.10±0.280^{f}
XLJ14	11.82±0.715^{h}	8.46±0.011^{h}	49.81±2.861^{ab}	23.75±0.684^{l}	6.18±0.023^{k}	20.27±0.255^{fg}	79.74±1.257^{e}	49.81±2.857^{b}	29.93±2.609^{k}
XL104	23.15±0.104^{pq}	11.57±0.018^{j}	45.61±0.897^{a}	18.94±0.203^{i}	0.74±0.016^{d}	34.72±0.057^{ij}	65.28±1.506^{ab}	45.61±0.078^{a}	19.68±0.134^{gh}
CDTC1	9.19±0.017^{g}	2.73±0.022^{b}	65.23±1.541^{f}	20.76±0.516^{j}	2.08±0.077^{h}	11.93±0.095^{c}	88.07±2.091^{h}	65.23±0.510^{fg}	22.84±0.607^{h}
HDDT 2	9.70±0.087^{g}	3.54±0.044^{c}	80.53±2.105^{j}	7.06±0.006^{b}	0.42±0.008^{b}	13.23±1.513^{d}	88.01±1.724^{h}	80.53±0.099^{j}	7.48±0.134^{c}
HDDT39	18.34±1.146^{n}	9.93±0.031^{i}	49.86±1.846^{ab}	20.63±5.44^{j}	1.26±0.082^{f}	28.27±1.195^{h}	71.74±1.224^{c}	49.86±1.460^{b}	21.89±2.259^{h}
Average	13.68	7.38	61.76	14.90	2.32	21.13	78.97	61.69	17.21
HD15	19.71±0.123^{o}	5.00±0.072^{e}	73.49±2.331^{gh}	1.03±0.016a	0.28±0.005^{a}	24.71±0.163^{g}	74.80±1.564^{d}	73.49±0.332^{i}	1.30±0.212^{a}

Cultivars	C16:0	C18:0	C18:1ω9	C18:2ω6	C18:3ω3	SFAs	UFAs	MUFAs	PUFAs
HD8	17.43±1.313^{m}	7.58±0.088^{g}	62.86±3.772^{e}	11.42±0.617^{e}	0.73±0.002^{d}	25.01±2.213^{g}	75.00±2.201^{d}	62.86±3.769^{f}	12.15±1.975^{d}
ZSHH	16.86±0.166^{lm}	2.12±0.028^{b}	69.32±1.578^{fg}	11.46±1.009^{e}	0.25±0.010^{a}	18.97±0.933^{f}	81.03±2.094^{ef}	69.32±0.566^{h}	11.71±1.506^{d}
JTHQ	12.62±0.380^{hi}	3.40±0.012^{c}	64.95±1.569^{ef}	15.74±0.015^{g}	3.31±0.062^{i}	16.01±1.921^{r}	83.99±1.492^{f}	64.95±5.685^{fg}	19.04±0.764^{g}
YXZBHQ	14.02±0.508^{j}	11.75±2.102^{j}	63.16±1.326e	9.93±0.351^{d}	1.15±0.021^{f}	25.77±2.044^{gh}	74.24±2.014^{d}	63.16±0.318^{f}	11.08±1.725^{d}
BLZ	13.73±2.035^{i}	5.46±0.059^{e}	61.95±1.156^{e}	18.10±0.443^{hi}	0.77±0.003^{d}	19.19±2.949^{f}	80.82±2.906^{e}	61.95±1.103^{rf}	18.87±1.052^{g}
XL34	14.86±0.166^{jk}	1.12±0.028^{a}	71.32±2.571^{g}	12.46±1.011^{ef}	0.26±0.010^{a}	15.97±0.933^{e}	84.04±1.948^{f}	71.32±0.566^{hi}	12.72±1.506^{de}
XL169	20.09±0.165^{o}	16.93±0.198^{m}	53.29±1.614^{c}	8.83±0.173^{c}	0.87±0.009^{de}	37.02±0.325^{k}	62.98±1.832^{a}	53.29±1.605^{de}	9.69±0.923^{c}
CS14	13.66±1.029^{i}	5.49±0.097^{e}	62.76±2.033^{e}	15.95±0.298^{g}	2.15±0.020^{h}	19.15±2.256^{f}	80.85±2.215^{e}	62.76±2.029^{f}	18.10±0.219^{g}
DZ1	5.55±0.017^{d}	6.89±0.029^{fg}	62.63±2.921^{e}	18.37±0.204^{hi}	6.53±0.018^{l}	12.44±1.117^{cd}	87.53±1.073^{gh}	62.63±2.920^{f}	24.90±1.853^{i}
NY7802	18.47±0.123^{n}	18.85±1.074^{n}	49.91±1.639^{ab}	12.12±0.498^{ef}	0.66±0.005^{c}	37.32±1.513^{k}	62.68±1.571^{a}	49.91±1.385^{b}	12.78±1.879^{de}
NY7810	6.88±0.103^{e}	4.52±0.072^{d}	64.55±1.943^{ef}	21.48±0.126^{k}	2.57±0.016^{hi}	11.40±0.624^{c}	88.60±1.629^{h}	64.55±0.941^{fg}	24.05±0.334^{i}
WSC26	18.25±0.717^{n}	13.30±0.122^{k}	55.24±1.545^{d}	12.59±0.011^{f}	1.14±0.019^{f}	31.55±0.290^{i}	68.96±1.742^{b}	55.24±0.502^{d}	13.73±0.078^{e}
YX1	17.43±0.506^{m}	15.20±1.048^{l}	55.48±1.552^{d}	10.34±0.193^{de}	1.56±0.037^{g}	32.63±0.983^{i}	67.38±1.918^{b}	55.48±1.549^{d}	11.90±0.566^{d}
YX8	13.63±0.140^{i}	11.98±1.006^{jk}	50.48±1.662^{b}	22.93±0.342^{kl}	1.00±0.00^{f}	25.61±0.658^{gh}	74.40±2.066^{d}	50.48±0.658^{b}	23.92±1.315^{hi}
YX9	16.15±0.514^{l}	3.72±0.086^{cd}	52.03±2.470^{bc}	23.99±0.621^{l}	4.12±0.042^{j}	19.87±0.714^{fg}	80.14±1.716^{e}	52.03±0.467^{c}	28.11±0.247^{j}
YX10	14.51±0.138^{j}	24.38±0.382^{o}	49.94±0.952^{ab}	9.77±0.213^{d}	1.41±0.058^{fg}	38.89±0.064^{k}	61.12±1.106 a	49.94±0.516^{b}	11.18±0.453^{d}
Average	14.95	9.65	60.27	13.43	1.71	24.59	75.41	60.26	15.14
Average	14.22	7.71	60.77	15.23	2.09	21.95	78.09	60.74	17.31
SD	5.652	5.479	9.073	6.091	2.308	9.269	9.786	9.602	7.501
CV	0.398	0.711	0.1493	0.4	1.105	0.422	0.125	0.158	0.433
F(0.05)	18.617**	37.500**	10.224**	15.503**	19.337**	27.372**	27.670**	10.224**	23.927**

Each value is the mean (standard deviation of duplicate determinations. Means with different letters in the column for each camellia seed oil are significantly different (Duncan Test, P < 0.05).

The compositions of the fatty acids in the *sn*-2 position of the camellia seed oils are shown in Table 3 and significant changes in the fatty acids of camellia seed oils in the *sn*-2 position were noticed ($P < 0.05$). In general, the *sn*-1 and *sn*-3 positions of triglycerides are usually bonded to saturated fatty acids, whereas the *sn*-2 position includes unsaturated ones. The *sn*-2 position was mainly occupied with oleic acid (60.77%, 45.61% ~ 82.96%), linoleic acid (15.23%, 0.88% ~ 33.18%), palmitic acid (14.22%, 2.37% ~ 25.24%), stearic acid (7.71%, 1.12% ~ 24.38%) and linolenic (2.09%, 0.25% ~ 12.35%) as shown in Table 3. Similar positional distributions of fatty acids have been reported in peanut oil [30] and camellia oil [31]. SFAs in *sn*-2 position distribution of EFC was higher than that of ECC, such as palmitic acid at 14.95% (5.55% ~ 20.09%) and 13.68% (2.37% ~ 25.24%) for EFC and ECC, respectively. stearic acid at 9.65% (1.12% ~ 24.38%) and 7.38% (1.60% ~ 16.93%) for EFC and ECC, respectively. As showed in Table 2, the SFAs contents of EFC was lower than that of ECC, these results about SFAs contents is not positively related to its distribution in *sn*-2 position, and further indicated distribution of fatty acids in *sn*-2 position is not random [32].

3.3. TGAs Composition

The fatty acid composition can be used to evaluate the stability and nutritional quality of fats and oils. While, it is essential to determine the type and amounts of TAGs species in the oil in order to appreciate their physical and functional properties [33]. TAGs are major components of oils and are derived from the esterification of glycerol with three fatty acids. Physical, nutritional and chemical properties of oils are highly associated with the composition and location of fatty acids in TAGs molecules [34].

Table 4. *Analysis of Triacylglycerols in 46 Camellia cultivars.*

Cultivars	LLLn	LLL	LLO	PLL	OOL+SLL	POL	PPL
XL1	0.02^{b}	0.08^{c}	0.28^{bc}	0.13^{de}	3.51±0.051^{b}	0.64±0.002^{cd}	0.02^{b}
XL5	0.01^{a}	0.05^{b}	0.17^{a}	0.08^{bc}	2.80±0.172^{a}	0.45±0.011^{b}	0.01^{a}
XL81	0.03^{c}	0.07^{c}	0.26^{bc}	0.13^{de}	3.46±0.311^{b}	0.65±0.013^{cd}	0.02^{b}
XL70	0.01^{a}	0.04^{b}	0.22^{b}	0.07^{b}	4.20±0.184^{dc}	0.78±0.008^{d}	-
XL97	0.01^{a}	0.04^{b}	0.19^{a}	0.08^{bc}	3.08±0.182^{b}	0.62±0.001^{cd}	-
XL27	0.02^{b}	0.06b^{c}	0.31^{c}	0.13^{de}	4.82±0.024^{cd}	0.81±0.006^{de}	-
XL124	0.01^{a}	0.05^{b}	0.25^{b}	0.11^{d}	3.81±0.067^{bc}	0.63±0.003^{cd}	0.03^{bc}
XL117	0.01^{a}	0.06b^{c}	0.27^{bc}	0.12^{de}	3.89±0.376^{bc}	0.71±0.018^{d}	0.02^{b}
XL92	0.02^{b}	0.08^{c}	0.49^{d}	0.16^{f}	6.18±0.003^{e}	1.20±0.008^{f}	-
XL63	-	0.15^{g}	0.75±0.006^{f}	0.22^{h}	7.07±0.061^{f}	1.31±0.003^{f}	0.04^{c}
XL67	0.02^{b}	0.09^{cd}	0.51^{e}	0.16^{f}	5.69±0.184^{de}	1.07±0.001^{ef}	0.01^{a}
XL69	0.07^{f}	0.06^{bc}	0.36^{c}	0.14e	5.06±0.050^{d}	0.87±0.001^{de}	0.03^{bc}
XL78	0.04^{d}	0.13^{f}	0.74±0.005^{f}	0.24^{i}	6.88±0.46^{ef}	1.42±0.012^{g}	0.01^{a}
XL121	0.01^{a}	0.05^{b}	0.23^{b}	0.1c	3.06±0.123^{b}	0.51±0.032^{bc}	0.02^{b}

Cultivars	LLLn	LLL	LLO	PLL	OOL+SLL	POL	PPL
XL97	0.02^{b}	0.06^{bc}	0.36^{c}	0.12^{d}	$5.16±0.073^{d}$	$0.97±0.006^{e}$	0.01^{a}
XL131	0.03^{c}	0.08^{e}	0.36^{c}	0.15^{ef}	$4.73±0.201^{cd}$	$0.93±0.011^{e}$	0.02^{b}
XLJ2	0.02^{b}	0.05^{b}	0.26^{bc}	0.09^{c}	$4.01±0.054^{c}$	$0.63±0.001^{cd}$	-
HS	0.02^{b}	0.08^{c}	0.36^{c}	0.16^{f}	$4.31±0.026^{c}$	$0.86±0.001^{de}$	0.01^{a}
HJ	0.02^{b}	0.07^{c}	0.28^{bc}	0.13^{de}	$3.55±0.040^{b}$	$0.77±0.001^{d}$	0.02^{b}
HX	0.02^{b}	0.05^{b}	0.20^{b}	0.10^{c}	$3.12±0.125^{b}$	$0.52±0.001^{bc}$	-
XL106	0.01^{a}	0.03^{ab}	0.18^{a}	0.07^{b}	$2.73±0.020^{a}$	0.52^{bc}	-
XL1210	0.01^{a}	0.01^{a}	0.27^{bc}	0.09^{c}	$3.96±0.055^{bc}$	$0.74±0.001^{d}$	-
LYHS	0.02^{b}	0.06^{bc}	0.33^{c}	0.11^{d}	$4.31±0.082^{c}$	$0.83±0.104^{de}$	-
HH	0.01^{a}	0.04^{b}	0.24^{b}	0.07^{d}	$3.69±0.057^{bc}$	$0.51±0.006^{bc}$	0.01^{a}
XLJ14	0.02^{b}	0.06^{bc}	0.34^{c}	0.15^{ef}	$4.74±0.188^{cd}$	$0.98±0.021^{e}$	0.02^{b}
XL104	0.01^{a}	0.04^{b}	0.17^{a}	0.09^{c}	$3.06±0.016^{b}$	$0.52±0.001^{bc}$	-
CDTC1	0.01^{a}	0.06^{bc}	0.36^{c}	0.11^{d}	$4.59±0.151^{cd}$	$0.89±0.007^{e}$	0.01^{a}
HDDT 2	0.02^{b}	0.09^{cd}	0.49^{d}	0.19^{g}	$5.60±0.030^{de}$	$1.14±0.019^{f}$	0.04^{c}
HDDT39	0.02^{b}	0.14^{f}	$0.89±0.005^{g}$	0.31^{j}	$7.89±0.081^{g}$	$2.31±0.009^{h}$	0.06^{d}
Average	0.02	0.07	0.35	0.13	4.44	0.85	0.01
HD15	0.03^{c}	$0.12±0.002^{df}$	$0.71±0.003^{f}$	0.22^{h}	$6.83±0.040^{ef}$	$1.51±0.011^{g}$	0.02^{b}
HD8	0.02^{b}	0.08^{c}	0.50^{e}	0.13^{e}	$6.00±0.163^{e}$	$0.99±0.004^{e}$	-
ZSHH	0.01^{a}	0.06^{bc}	0.34^{c}	0.12^{de}	$4.83±0.089^{cd}$	$0.83±0.003^{de}$	-
JTHQ	0.02^{b}	0.03^{ab}	0.19^{a}	0.10^{c}	$2.87±0.015^{a}$	0.46^{b}	-
YXZBHQ	0.02^{b}	0.07^{c}	0.38^{c}	0.14^{e}	$5.01±0.012^{d}$	$0.83±0.002^{de}$	-
BLZ	0.02^{b}	$0.11±0.003^{d}$	$0.57±0.001^{e}$	0.19g	$6.10±0.251^{e}$	$1.27±0.002^{f}$	0.01^{a}
XL34	0	0.06^{bc}	0.36^{c}	0.11d	$4.84±0.017^{cd}$	$0.91±0.001^{e}$	0.01^{a}
XL169	0.04^{d}	0.11d	0.56^{e}	0.19g	$6.03±0.051^{e}$	$1.16±0.005^{f}$	0.04^{c}
CS14	0.02^{b}	0.06^{bc}	0.24^{b}	0.10c	$3.42±0.141^{b}$	$0.82±0.007^{de}$	-
DZ1	0.03^{c}	0.02a	0.25^{b}	0.02a	$6.37±0.057^{e}$	$0.13±0.004^{a}$	0.01^{a}
NY7802	0.02^{b}	0.08^{c}	0.43^{d}	0.15^{ef}	$4.71±0.261^{cd}$	$0.93±0.008^{e}$	-
NY7810	0.02^{b}	0.03^{ab}	0.17^{a}	0.06^{b}	$2.66±0.051^{a}$	$0.49±0.001^{b}$	0.01^{a}
WSC26	0.01^{a}	0.05^{b}	0.24^{b}	0.09^{c}	$3.62±0.051^{bc}$	$0.57±0.001^{c}$	-
YX1	0.02^{b}	0.07^{c}	0.37^{c}	0.17^{f}	$5.41±0.022^{d}$	$1.03±0.004^{ef}$	0.02^{b}
YX8	0.03^{c}	0.05^{b}	0.18a	0.09^{c}	$2.74±0.053^{a}$	0.47^{b}	-
YX9	0.06^{e}	0.21^{h}	$1.01±0.009^{h}$	$0.50l^{k}$	$10.33±0.036^{h}$	$2.79±0.019^{i}$	0.07^{d}
YX10	0.02^{b}	0.06^{bc}	0.3^{c}	0.13^{e}	$4.10±0.033^{c}$	$0.73±0.013^{d}$	0.01^{a}
Average	0.02	0.07	0.40	0.15	5.05	0.93	0.01
Average	0.02	0.07	0.37	0.14	4.67	0.88	0.01
SD	0.013	0.037	0.195	0.076	1.569	0.46	0.016
CV	0.638	0.525	0.529	0.551	0.336	0.52	1.251
F(0.05)	64228.566**	9.315**	15.138**	16.004**	17.754**	21.647**	2.967**

***Table 4.** Continued.*

Cultivars	OOO+SLO	OOP	POP	SOO	SLS	POS
XL1	$80.96±2.415^{de}$	$11.08±0.105^{d}$	0.17^{g}	0.20^{d}	$2.83±0.008^{fg}$	0.10^{d}
XL5	$83.37±2.817^{fg}$	$10.01±0.022^{c}$	0.06^{bc}	0.18^{cd}	$2.72±0.012^{g}$	0.09^{d}
XL81	$81.94±1.836^{e}$	$9.56±0.608^{bc}$	0.09^{cd}	0.21^{de}	$3.45±0.044^{h}$	0.15^{fg}
XL70	$80.70±3.736^{d}$	$12.28±0.138^{e}$	0.05^{b}	0.13^{b}	$1.48±0.016^{cd}$	0.06^{b}
XL97	$81.56±2.737^{e}$	$12.11±0.150^{e}$	0.13^{e}	0.16^{c}	$1.92±0.013^{ef}$	0.09^{d}
XL27	$80.82±1.119^{d}$	$11.16±0.102^{d}$	0.04^{b}	0.16^{c}	$1.62±0.011^{d}$	0.05^{b}
XL124	$81.90±2.281^{e}$	$9.89±0.019^{c}$	0.05^{b}	0.17^{c}	$2.98±0.118^{g}$	0.12e
XL117	$82.50±1.714^{f}$	$10.36±0.179^{c}$	0.05^{b}	0.21^{de}	$1.71±0.021^{f}$	0.08c
XL92	$78.67±1.702^{cd}$	$12.02±0.434^{e}$	0.06^{bc}	0.15^{b}	$0.96±0.013^{ab}$	0.02^{a}
XL63	$78.33±1.289^{cd}$	$10.44±0.105^{c}$	0.17^{g}	0.17^{c}	$1.28±0.018^{c}$	0.06^{b}
XL67	$78.79±2.734^{cd}$	$11.77±0.503^{de}$	0.07^{c}	0.17^{c}	$1.58±0.013^{d}$	-
XL69	$79.50±2.246^{d}$	$11.42±0.089^{de}$	0.14^{e}	0.18^{cd}	$2.10±0.016^{f}$	0.08^{c}
XL78	$77.35±1.666^{c}$	$11.61±0.312^{de}$	0.17^{g}	0.20^{d}	$1.17±0.014^{b}$	0.06^{b}
XL121	$83.96±1.429^{fg}$	$9.43±0.314^{b}$	0.07^{c}	0.19^{d}	$2.29±0.079^{f}$	0.08^{c}
XL97	$78.43±1.699^{cd}$	$12.39±0.115^{e}$	0.08^{c}	0.14^{b}	$2.16±0.189^{f}$	0.11^{e}
XL131	$78.94±1.189^{cd}$	$11.81±0.149^{de}$	0.08^{c}	0.21^{de}	$2.56±0.176^{fg}$	0.10^{d}
XLJ2	$81.76±2.246^{e}$	$10.73±0.109^{cd}$	0.04^{b}	0.14^{b}	$2.19±0.076^{f}$	0.08^{c}
HS	$80.87±1.254^{d}$	$10.59±0.481^{cd}$	0.18^{g}	0.20^{d}	$2.25±0.065^{f}$	0.11^{e}
HJ	$79.68±2.083^{d}$	$12.44±1.551^{e}$	0.11^{d}	0.20^{d}	$2.61±0.055^{fg}$	0.13^{f}
HX	$83.75±1.936^{fg}$	$9.67±0.115^{bc}$	0.02^{a}	0.19^{d}	$2.28±0.070^{f}$	0.09^{d}
XL106	$82.66±1.107^{f}$	$10.43±0.165^{cd}$	0.08^{c}	0.13^{b}	$3.06±0.204^{g}$	0.11^{e}
XL1210	$81.46±2.223^{e}$	$11.29±0.124^{d}$	0.14e	0.21^{de}	$1.70±0.014^{f}$	0.08^{c}

Cultivars	OOO+SLO	OOP	POP	SOO	SLS	POS
LYHS	80.88±2.745d	11.08±0.120d	0.12de	0.18cd	1.96±0.020ef	0.10d
HH	84.42±2.137g	8.96±0.102ab	0.02a	0.14b	1.85±0.015f	0.06b
XLJ14	79.81±1.745d	12.18±0.179e	0.17g	0.18cd	1.30±0.041c	0.06b
XL104	83.18±1.044f	10.89±0.114cd	0.07c	0.15b	1.76±0.001f	0.06b
CDTC1	79.86±1.299d	11.51±0.106d	0.09cd	0.10a	2.33±0.015f	0.09d
HDDT 2	79.38±1.297d	10.90±0.154cd	0.19gh	0.20d	1.67±0.019de	0.10d
HDDT39	71.77±1.277b	15.36±0.101fg	0.27i	0.13b	0.80±0.002a	0.05b
Average	80.60	11.15	0.10	0.17	2.02	*0.084*
HD15	76.47±1.544c	12.88±0.273e	0.14e	0.19d	0.84±0.016a	0.05b
HD8	80.90±2.407de	9.68±0.315bc	0.03a	0.15bc	1.46±0.017cd	0.05b
ZSHH	81.80±2.021e	10.19±0.152c	0.03a	0.17c	1.56±0.042d	0.05b
JTHQ	85.88±1.243h	8.17±0.109a	0.03a	0.18cd	1.99±0.016ef	0.08c
YXZBHQ	81.97±2.678e	9.90±0.079c	0.08c	0.17c	1.40±0.016c	0.05b
BLZ	78.27±1.671cd	11.80±0.109de	0.13e	0.17c	1.30±0.313c	0.07c
XL34	81.82±2.040e	10.50±0.114cd	0.15f	0.15bc	1.03±0.001b	0.05b
XL169	78.23±1.218cd	11.67±0.212d	0.11d	0.23e	1.59±0.074df	0.07c
CS14	78.96±1.693cd	14.48±0.224f	0.09cd	0.15bc	1.56±0.011d	0.10d
DZ1	78.70±2.171cd	11.29±0.053d	0.20h	0.20d	1.87±0.015e	0.11e
NY7802	80.07±2.257d	10.83±0.41c	0.04b	0.16c	2.49±0.122fg	0.08c
NY7810	82.91±2.214f	10.26±0.122c	0.11d	0.13b	3.04±0.014g	0.11e
WSC26	84.51±2.376g	9.12± 0.145b	0.02a	0.15bc	1.56±0.010d	0.06b
YX1	79.10±1.225d	12.14±0.184e	0.07c	0.18cd	1.37±0.058c	0.07c
YX8	83.44±3.219fg	9.33±0.122b	0.03a	0.18cd	3.36±0.014h	0.12e
YX9	66.08±1.107a	16.74±0.203g	0.47j	0.14b	1.45±0.100cd	0.14f
YX10	81.81±3.102e	10.25±0.127c	0.06bc	0.18cd	2.27±0.013f	0.09d
Average	80.05	11.13	0.10	0.17	1.77	0.079
Average	80.39	11.14	0.10	0.17	1.93	0.082
SD	3.288	1.591	0.08	0.028	0.659	0.028
CV	0.041	0.143	0.769	0.163	0.342	0.334
F(0.05)	16.809**	16.952**	7.101**	1.998**	10.548**	3.304**

Means with undetected. Each value is the mean (standard deviation of duplicate determinations. Means with different letters in the column for each camellia seed oil are significantly different (Duncan Test, P < 0.05).

As shown in Table 4, changes in the TAGs compositions of camellia seed oils were found to be significant (P < 0.05). Twenty six kinds of TAGs has been found in camellia oil in previously report [35], but in present paper, fifteen TAG species were identified, mainly including triolein+stearolinoleoolein (OOO + SLO, average value with 80.39%), dioleoplamitoin (OOP, average value with 11.14%) dioleolinolein+stearodilinolein(OOL+SLL, average value with 4.67%) and stearolinoleostearolein (SLS, average value with 1.93%). Among, camellia seed oil from the JTHQ contained the highest amount of the OOO + SLO TAG species (85.88%). The three major TAG in camellia oil are OOO, OOP and OOL, and the results were similar with the report [31, 36] but different with the report [37]. In Alam´s report, 15 kinds of TAGs were separated and identified in camellia seed oil after auto-oxidation, including palmitodiolein (POO), OOO, oleiolinoleoolein (OLO), palmitooleolinolein (PLO), oleodilinolein (OLL), stearodiolein (SOO) and oleiolinoleolinolenin (OLLn) [37], the reason of results different with our data in this paper maybe attribute to auto-oxidation.

There is a small amount of SFAs (9.21%) in total (Table 2). So, the trisaturated TAGs species were not detected, but the disaturated TAGs species, such as dipalmitoyl-linoleoylglyecerol (PPL), was detected in some cultivars, including YX9 (0.07%), HDDT 39 (0.06%), XL169 (0.04%), XL63 (0.04%) and HDDT2(0.04%), the average amounts of disaturated TAGs species PPL was 0.01% (0 ~ 0.07%). The palmitic acid is attached at *sn*-1/3 position and palmitic acid at *sn*-2 position is only about 0.02% (0 ~ 0.12%), these results are in agreement with the report [31]. But, stearic acid is attached at *sn*-1/3 position and stearic acid at *sn*-2 is not detected in this work. Meantime, the determination amounts of LLO, Trilinolein (LLL), and dilinoleolinolenin (LLLn) appear with trace in this work.

There are no significant difference between EFC and ECC for average contents of TGAs, but some difference among of cultivars. The lowest and highest contents of OOO+SLO was cultivars HDDT39 (71.77%) and cultivars HH (84.42%) for ECC, but it was the cultivars YX9 (66.08%) and cultivars JTHQ (85.88%) for EFC, respectively. All these results indicated TGAs contents and species have no obviously difference between EFC and ECC, but small difference in some cultivars maybe due to the different climate and geographical environments.

3.4. Equivalent Carbon Number (ECN)

The digestion, absorption, and physiology characteristics of TAGs are strongly affects by TAGs molecular species [30, 38, 39]. Therefore, it is very important to quantify and evaluate the TAGs molecular species in fats and oils using ECN. The ECN is defined by the equation ECN＝TCN - 2×DB, where TCN is the total acyl carbon number and DB is the total double bond number in the three fatty acids esterified on the TAGs molecule [40]. Furthermore, a linear relationship exists between ECN and the carbon number of the triacylglycerol which showed the same unsaturation characteristics.

The ECN in camellia seed oils are summarized in Table 5 and significant differences in the ECN of camellia seed oils were found (P < 0.05). Six TAG molecular species were identified, mainly including ECN48 (average value with 91.64%), ranged from 83.30% in YX9 cultivar to 94.14% in XL104 cultivar, ECN46 (5.44%), ECN50 (2.18%), ECN44 (0.50%), ECN40 (0.17%), and ECN42 (0.07%) (shown in Table 5). The amounts of ECN48 was higher than olive oil of reported [41] and may be used as a tool for adulteration of camellia seed oil with other oils.

Table 5. *Analysis of ECN in Triacylglycerols in 46 camellia cultivar.s*

Cultivars	ECN40	ECN42	ECN44	ECN46	ECN48	ECN50
XL1	0.02^{b}	0.08^{c}	0.41^{c}	$4.17±0.101^{c}$	$92.21±1.923^{d}$	$3.13±0.012^{fg}$
XL5	0.01^{a}	0.05^{b}	0.25^{a}	$3.26±0.007^{b}$	$93.44±0.235^{e}$	$2.99±0.034^{f}$
XL81	$0.03±0.007^{c}$	0.07^{c}	$0.39±0.071^{b}$	$4.13±0.438^{c}$	$91.59±1.160^{c}$	$3.81±0.601^{h}$
XL70	0.005^{a}	0.04^{ab}	$0.29±0.028^{ab}$	$4.97±0.255^{cd}$	$93.03±0.368^{e}$	$1.67±0.071^{c}$
XL97	0.01^{a}	0.04^{ab}	$0.28±0.071^{ab}$	$3.70±0.198^{bc}$	$93.80±0.325^{e}$	$2.18±0.134^{e}$
XL27	0.02^{b}	0.06^{b}	$0.44±0.028^{c}$	$5.63±0.057^{d}$	$92.03±0.134^{d}$	$1.84±0.035^{d}$
XL124	0.02^{b}	0.05^{b}	$0.36±0.028^{b}$	$4.47±0.021^{c}$	$91.84±0.156^{c}$	$3.28±0.191^{g}$
XL117	0.02^{b}	0.06^{b}	$0.39±0.071^{b}$	$4.62±0.509^{c}$	$92.92±0.898^{d}$	$1.99±0.304^{d}$
XL92	0.02^{b}	0.08^{c}	0.65^{e}	$7.38±0.256^{g}$	$90.75±0.997^{c}$	1.13^{ab}
XL63	0.03^{c}	0.15^{g}	0.97^{g}	$8.42±0.345^{h}$	$88.94±1.241^{b}$	1.51^{b}
XL67	0.02^{b}	0.09^{d}	0.67^{e}	$6.77±0.431^{f}$	$90.63±1.352^{c}$	$1.82±0.002^{cd}$
XL69	0.07^{f}	0.06^{b}	0.50^{d}	$5.96±0.231^{de}$	$91.06±0.987^{c}$	$2.36±0.003^{e}$
XL78	0.04^{d}	$0.13±0.028^{e}$	$0.98±0.050^{g}$	$8.30±0.488^{h}$	$89.13±0.417^{bc}$	$1.44±0.014^{b}$
XL121	0.02^{b}	0.05^{b}	$0.33±0.019^{b}$	$3.59±0.570^{bc}$	$93.47±1.011^{e}$	$2.57±0.771^{e}$
XL97	0.02^{b}	0.06^{b}	$0.47±0.056^{c}$	$6.15±0.156^{f}$	$90.90±0.509^{c}$	$2.41±0.289^{e}$
XL131	0.03^{c}	0.09^{c}	$0.5±0.071^{d}$	$5.68±0.325^{d}$	$90.84±0.693^{c}$	$2.88±0.247^{f}$
XLJ2	0.02^{b}	0.06^{b}	$0.35±0.035^{b}$	$4.64±0.042^{c}$	$92.53±0.148^{d}$	$2.41±0.071^{e}$
HS	0.03^{c}	0.08^{c}	$0.52±0.085^{d}$	$5.19±0.339^{d}$	$91.65±0.742^{c}$	$2.56±0.276^{e}$
HJ	0.03^{c}	0.07^{bc}	$0.41±0.021^{c}$	$4.34±0.420^{c}$	$92.24±0.559^{d}$	$2.94±0.191^{f}$
HX	0.02^{b}	0.05^{b}	$0.30±0.078^{b}$	$3.64±0.147^{bc}$	$93.45±0.757^{e}$	$2.56±0.799^{e}$
XL106	0.01^{a}	0.04^{ab}	$0.25±0.014^{a}$	$3.25±0.219^{b}$	$93.17±0.438^{e}$	$3.31±0.247^{g}$
XL1210	0.01^{a}	0.05^{b}	0.36^{b}	$4.70±0.036^{cd}$	$92.89±1.254^{de}$	$1.99±0.023^{d}$
LYHS	0.02^{b}	0.06^{b}	$0.44±0.085^{c}$	$5.15±0.212^{d}$	$92.09±0.608^{d}$	$2.25±0.304^{e}$
HH	0.01^{a}	0.04^{ab}	$0.32±0.035^{b}$	$4.20±0.028^{c}$	$93.40±0.148^{e}$	$2.05±0.085^{e}$
XLJ14	0.02^{b}	0.065^{b}	$0.49±0.092^{c}$	$5.74±0.096^{de}$	$92.16±0.813^{d}$	$1.54±0.410^{b}$
XL104	0.01^{a}	0.04^{ab}	$0.27±0.021^{a}$	$3.58±0.023^{bc}$	$94.14±0.057^{de}$	$1.97±0.028^{d}$
CDTC1	0.01^{a}	0.06^{b}	$0.48±0.071^{c}$	$5.48±0.226^{d}$	$91.46±0.410^{c}$	$2.53±0.092^{e}$
HDDT 2	0.02^{b}	0.10^{d}	$0.68±0.071^{e}$	$6.77±0.396^{f}$	$90.48±0.714^{c}$	$1.97±0.233^{d}$
HDDT39	0.02^{b}	0.14^{f}	$1.21±0.035^{h}$	$10.26±0.170^{i}$	$87.41±0.247^{b}$	$0.99±0.021^{a}$
Average	0.02	0.07	0.48	5.31	91.85	2.27
HD15	0.03^{c}	0.12^{e}	0.93^{g}	$8.36±0.007^{h}$	$89.49±0.124^{b}$	$1.08±0.002^{a}$
HD8	0.02^{b}	0.08^{c}	$0.63±0.014^{e}$	$7.00±0.113^{fg}$	$90.61±0.050^{c}$	$1.68±0.035^{bc}$
ZSHH	0.02^{b}	0.06^{b}	$0.47±0.050^{c}$	$5.67±0.926^{d}$	$92.02±0.523^{d}$	$1.78±0.453^{c}$
JTHQ	0.02^{b}	0.03^{a}	0.29^{a}	$3.33±0.025^{b}$	$94.08±1.452^{de}$	$2.25±0.016^{e}$
YXZBHQ	0.02^{b}	0.07^{c}	$0.52±0.049^{d}$	$5.85±0.233^{de}$	$91.95±0.191^{d}$	$1.62±0.127^{bc}$
BLZ	0.02^{b}	0.11^{c}	$0.77±0.021^{f}$	$7.38±0.283^{g}$	$90.20±0.509^{c}$	$1.53±0.028^{b}$
XL34	-	0.06^{b}	$0.47±0.002^{c}$	$5.76±0.054^{de}$	$92.47±1.672^{d}$	$1.23±0.071^{b}$
XL169	0.04^{d}	0.11^{d}	$0.75±0.071^{f}$	$7.23±0.087^{g}$	$90.01±1.211^{c}$	$1.89±0.006^{d}$
CS14	0.02^{b}	0.06^{b}	0.34^{b}	$4.24±0.123^{c}$	$93.53±1.213^{e}$	$1.81±0.001^{cd}$
DZ1	$6.83±0.007^{g}$	0.02^{a}	0.27^{a}	0.51^{a}	$90.19±0.978^{c}$	$2.18±0.008^{e}$
NY7802	0.02^{b}	0.08^{c}	$0.58±0.052^{d}$	$5.65±0.670^{d}$	$90.95±3.210^{c}$	$2.74±0.054^{ef}$
NY7810	0.02^{b}	0.04^{ab}	$0.23±0.014^{a}$	$3.16±0.049^{b}$	$93.29±0.021^{e}$	$3.28±0.057^{g}$
WSC26	0.01^{a}	0.05^{b}	0.33^{b}	$4.19±0.014^{c}$	$93.65±1.234^{e}$	$1.77±0.005^{c}$
YX1	0.02^{b}	0.07^{c}	$0.54±0.127^{d}$	$6.46±0.269^{f}$	$91.30±1.061^{e}$	$1.61±0.636^{bc}$
YX8	0.03^{c}	0.05^{b}	0.27^{a}	$3.21±0.046^{b}$	$92.80±0.415^{c}$	$3.66±0.091^{h}$
YX9	0.06^{e}	$0.21±0.006^{h}$	$1.51±0.028^{i}$	$13.20±0.085^{j}$	$83.30±0.035^{a}$	$1.74±0.007^{c}$
YX10	0.02^{b}	0.06^{b}	$0.43±0.092^{c}$	$4.85±0.467^{c}$	$92.12±0.778^{d}$	$2.54±0.184^{e}$
Average	*0.42*	*0.07*	*0.55*	*5.65*	*91.29*	*2.02*
Average	0.17	0.07	0.50	5.44	91.64	2.18
SD	1.004	0.035	0.265	2.12	1.951	0.684
CV	5.952	0.506	0.526	0.39	0.021	0.313
F(0.05)	26862.538**	15.549**	30.847**	36.309**	39.483**	21.383**

Means with undetected. Each value is the mean (standard deviation of duplicate determinations. Means with different letters in the column for each camellia seed oil are significantly different (Duncan Test, P < 0.05).

Beside of ECN40，there has no significant difference between EFC and ECC for ECN, the average ECN40 was 0.02% for ECC, but it was 0.42% for EFC(cultivars DZ1, 6.83%), Comprehensive LLLn values in Tables 4, significant differences should not be attributed to the cultivars but the experiment error caused. Meantime the distribution information of ECN also showed that the distribution of ECC was more uniform than that of EFC. The contents of ECN42, ECN44 and ECN46 of camellia seed oil in present work were lower than that of rapeseed oil, corn oil, soybean oil, sunflower oil, grape seed oil, rice bran oil, peanut oil and cottonseed oil, but ECN50 was higher than that of reports [42], results in this work further indicated the contents of saturated fatty acids distribution in *sn*-1/3 is higher than that of reports [32]. To the best of the authors' knowledge, this is the first literature data for comparison of the ECN of camellia seed oil from different cultivars.

4. Conclusion

In this study, fatty acid profile, *sn*-2 fatty acids distribution and TAGs of seed oil of 46 different *Camellia* cultivars in Hunan province were evaluated. Five fatty acids were identified and the most contribution to the total is oleic acid (18:1ω9). The *sn*-2 position was mainly occupied with oleic acid, linoleic acid and palmitic acid. Fifteen TAGs species were identified, mainly including OOO + SLO, OOP and OOL+SLL. The trisaturated TAGs species were not detected, only PPL of disaturated TAGs species was detected in some cultivars. These results in present paper indicated different *Camellia* cultivars have no obviously influence on profiles of fatty acids, *sn*-position distribution and TGAs, but on contents of these in camellia seed oil($P < 0.05$). SFAs concentration is not positively related to its distribution in *sn*-2 position. TGAs contents and species have small difference in some cultivars maybe due to the different climate and geographical environments. To our latest knowledge, there are no reports available on the fatty acids located on the *sn*-2 position and TAG contents and molecular species of seed oils obtained different *Camellia* cultivars; hence, the data in this study may be important as a reference for adulteration of camellia seed oil with other oils, and can also be used for further bud grafting or seed propagation, specifically for the production of fatty acids.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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