Lipid Soluble Green Tea Extract (LSGT): A New Natural Flavoring with Excellent Oil-stabilization and Anti-oxidative Properties in Food Emulsions and Frying Oils

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1. Introduction of lipid soluble green tea extract (LSGT)
Lipid soluble green tea extract

- Esters of green tea extract (water soluble catechins) and fatty acids (palmitic acids)
- Listed as FEMA No. 4812 "Palmitoylated Green tea extract" under the 27th publication by the Expert Panel of the Flavor and Extract Manufacturers Association (FEMA)

Structure of LSGT (one isomer)
Properties of LSGT

From green tea, naturally exists

<table>
<thead>
<tr>
<th>Green tea variety</th>
<th>LSGT versus free catechins (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KN1325 retain</td>
<td>0.15</td>
</tr>
<tr>
<td>Lipton Green Tea</td>
<td>0.22</td>
</tr>
<tr>
<td>Dragon’s Well</td>
<td>8.04</td>
</tr>
<tr>
<td>Snow Dragon</td>
<td>0.34</td>
</tr>
<tr>
<td>Tai Ping Hou Kwei</td>
<td>0.40</td>
</tr>
<tr>
<td>No. 9 Yunnan</td>
<td>0.20</td>
</tr>
</tbody>
</table>

W/O stabilization

Heat mayo from freezer to 60 °C

J. Agric. Food Chem. 2013, 61, 11484–11493
2. LSGT with anti-oxidative properties in edible oils

- OSI study in sunflower/peanut/soybean/canola oils
- Accelerated storage study in soybean/canola oils
OSI results (hours, 100 °C)

**Soybean oil**
- Untreated: 9.80
- AP 200 ppm: 21.45
- MT90 200 ppm: 10.60
- R40 500 ppm: 13.38
- LSC 100 ppm: 15.50
- LSC 200 ppm: 18.08
- LSC 400 ppm: 23.60
- TBHQ 80 ppm: 24.85

**Canola oil**
- Untreated: 14.70
- AP 200 ppm: 18.08
- MT90 200 ppm: 14.80
- R40 500 ppm: 18.10
- LSC 100 ppm: 20.10
- LSC 200 ppm: 25.55
- LSC 400 ppm: 34.00
- TBHQ 80 ppm: 40.40

**Sunflower oil**
- Untreated: 6.08
- LS6G 60 ppm: 10.73
- LS6G 200 ppm: 12.70
- LS6G 400 ppm: 15.95
- MT90 200 ppm: 19.45
- R40 200 ppm: 7.25
- TBHQ 100 ppm: 19.60

**Peanut oil**
- Untreated: 16.05
- AP 200 ppm: 17.50
- R40 500 ppm: 17.68
- LSC 100 ppm: 19.75
- LSC 200 ppm: 23.93
- LSC 400 ppm: 33.60
- LSC 600 ppm: 42.65
- TBHQ 80 ppm: 28.95

**Ingredients**
- AP - ascorbyl palmitate
- MT90 – mixed tocopherols
- R40 – rosemary extract
- LSC/LSGT – lipid soluble green tea extract
Accelerated storage

**Soybean oil**

- Peroxide Value (meq/kg fat)
- Weeks, 28~30 °C no light exposure

**Canola oil**

- Peroxide Value (meq/kg fat)
- Weeks, 28~30 °C no light exposure
Summary

- LSGT performs better than tocopherols and rosemary extracts in all 4 types of edible oils

- LSGT performs better than AP in canola/sunflower/peanut oil, and is comparable to AP in soybean oil

- Relatively high dosage of LSGT (400-600 ppm) shows similar antioxidant ability to TBHQ (80-200 ppm)
3. Application of LSGT in food emulsions

- Mayonnaise
- Margarine
### Mayonnaise

#### Peroxide Values (PV)

- **Ingredient**
  - Soybean Oil: 75.00%
  - Salt: 0.61%
  - Egg Yolks, 10% salt: 8.89%
  - Ground Mustard: 1.00%
  - Heinz Distilled White Vinegar: 12.60%
  - Water: 1.90%

#### Alkenals

- **Ingredients**
  - Negative Control
  - FORTIUM R30 500 ppm
  - LSGT 500 ppm
  - 75 ppm EDTA
Margarine (35 °C storage)

- Raw oil (melting point at 38-42°C) contained palm oil, soybean oil, unknown emulsifier, flavor and pigment at unknown ratios.

- The resulted margarine was composed of 84% raw oil and 16% distilled water.

➤ LSGT is the best AO to stabilize margarine
Margarine – plant trial

- Made at 100 kg scale in a margarine factory
- Stored at 4 °C fridge and analyzed monthly for 12 month

<table>
<thead>
<tr>
<th>PV (meq/kg fat)</th>
<th>2015/5/7</th>
<th>2015/6/3</th>
<th>2015/6/29</th>
<th>2015/7/31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1 – Tocopherols (200 ppm)</td>
<td>0.719</td>
<td>3.208</td>
<td>2.654</td>
<td>10.154</td>
</tr>
<tr>
<td>Sample 2 – LSGT (200 ppm)</td>
<td>0.943</td>
<td>4.083</td>
<td>3.026</td>
<td>5.206</td>
</tr>
</tbody>
</table>
4. Application of LSGT in frying oils

- Formula screening by mini-frying
- Mixture of ingredient blends with antioxidative capabilities in frying soybean oil
- Mixture of ingredient blends with antioxidative capabilities in frying palm oil
Why do we blend LSGT, RE and MT?

- Preliminary screening showed LSGT+RE+AP and LSGT+RE+MT showed good performance in stabilizing frying oils.
- Blend 122 and 123 was picked up for scale up frying soybean oil study.
- Blend 154 (=TRLG103) and 124 (=TRLG101) was picked up for scale up frying palm oil study.
Formula screening by mini-frying

Screening trial #3

<table>
<thead>
<tr>
<th>#</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Untreated</td>
</tr>
<tr>
<td>2</td>
<td>TBHQ</td>
</tr>
<tr>
<td>3</td>
<td>AP</td>
</tr>
<tr>
<td>4</td>
<td>MT</td>
</tr>
<tr>
<td>5</td>
<td>RE</td>
</tr>
<tr>
<td>6</td>
<td>LSGT</td>
</tr>
<tr>
<td>7</td>
<td>LSGT+RE</td>
</tr>
<tr>
<td>8</td>
<td>LSGT+RE+AP</td>
</tr>
<tr>
<td>9</td>
<td>LSGT+MT</td>
</tr>
<tr>
<td>10</td>
<td>RE+MT</td>
</tr>
<tr>
<td>11</td>
<td>RE+MT+AP</td>
</tr>
<tr>
<td>12</td>
<td>Blend 111</td>
</tr>
<tr>
<td>13</td>
<td>Blend 122</td>
</tr>
<tr>
<td>14</td>
<td>Blend 133</td>
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<tr>
<td>15</td>
<td>Blend 212</td>
</tr>
<tr>
<td>16</td>
<td>Blend 223</td>
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<tr>
<td>17</td>
<td>Blend 231</td>
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<tr>
<td>18</td>
<td>Blend 313</td>
</tr>
<tr>
<td>19</td>
<td>Blend 321</td>
</tr>
<tr>
<td>20</td>
<td>Blend 332</td>
</tr>
</tbody>
</table>
Carbonyl value and color of frying oil

Carbonyl value (meq/kg)

- Batch 20
- Batch 30

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Carbonyl Value (meq/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>17</td>
</tr>
<tr>
<td>TBHQ</td>
<td>15</td>
</tr>
<tr>
<td>AP</td>
<td>14</td>
</tr>
<tr>
<td>MT</td>
<td>13</td>
</tr>
<tr>
<td>RE</td>
<td>12</td>
</tr>
<tr>
<td>LSC</td>
<td>11</td>
</tr>
<tr>
<td>LSC+RE</td>
<td>10</td>
</tr>
<tr>
<td>LSC+RE+AP</td>
<td>9</td>
</tr>
<tr>
<td>LSC+MT</td>
<td>8</td>
</tr>
<tr>
<td>RE+MT</td>
<td>7</td>
</tr>
<tr>
<td>RE+MT+AP</td>
<td>6</td>
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<tr>
<td>Blend 111</td>
<td>5</td>
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<tr>
<td>Blend 122</td>
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<tr>
<td>Blend 133</td>
<td>3</td>
</tr>
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<td>Blend 212</td>
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<td>Blend 223</td>
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<td>Blend 313</td>
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<td>Blend 321</td>
<td>0</td>
</tr>
<tr>
<td>Blend 332</td>
<td>0</td>
</tr>
</tbody>
</table>

Carbonyl value and color of frying oil for different treatments and batches.
## Conclusion

<table>
<thead>
<tr>
<th>Most promising blend</th>
<th>Confirmed by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blend 122</td>
<td>Frying result and DOE analysis</td>
</tr>
<tr>
<td>Blend 133</td>
<td>Frying result</td>
</tr>
<tr>
<td>Blend 123</td>
<td>DOE analysis</td>
</tr>
</tbody>
</table>

- Combination of LSGT, rosemary extract and mixed-tocopherols showed the best efficacy in protecting frying oils
- Blend 122 and 123 was chosen for real frying trials
Soybean oil

Treatment
A. Untreated
B. TBHQ, 100 ppm
C. Blend 122, 300 ppm
D. Blend 123, 300 ppm

Frying parameters
- 3.4 kg frying oil
- French fries, 150 g per batch
- 3 m 10 s frying time
- Collect fries and frying oils every 10 batch
Color of fries and frying oil

Batch 10

Batch 20

Batch 30

Batch 40
Analysis of frying oil

**Total Polar Compound (TPC)**

- A. Untreated
- B. TBHQ
- C. Blend 122
- D. Blend 123

**Acid Value**

- A. Untreated
- B. TBHQ
- C. Blend 122
- D. Blend 123

**Carbonyl Value**

- A. Untreated
- B. TBHQ
- C. Blend 122
- D. Blend 123

**Red Color Score**

- A. Untreated
- B. TBHQ
- C. Blend 122
- D. Blend 123
### TPC tested by different method

<table>
<thead>
<tr>
<th>Treatment (batch 40)</th>
<th>TPC by silica gel method (GBT5009.202-2003)</th>
<th>TPC by Testo 270</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Untreated</td>
<td>23.2%</td>
<td>24.9%</td>
<td>1.7%</td>
</tr>
<tr>
<td>B. TBHQ</td>
<td>25.6%</td>
<td>26.0%</td>
<td>0.4%</td>
</tr>
<tr>
<td>C. Blend 122</td>
<td>23.1%</td>
<td>25.0%</td>
<td>1.9%</td>
</tr>
<tr>
<td>D. Blend 123</td>
<td>10.0%</td>
<td>15.0%</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

### OSI of fresh oil and abused oil

![Graph showing OSI at 110°C for different treatments]

- **Fresh oil**
  - A. Untreated: 4.35
  - B. TBHQ: 13.40
  - C. Blend 122: 4.15
  - D. Blend 123: 4.30

- **Abused oil**
  - A. Untreated: 1.90
  - B. TBHQ: 1.85
  - C. Blend 122: 2.05
  - D. Blend 123: 4.25
Palm oil (Instant noodles)

**Treatment**
- A. Untreated
- B. RE+ascorbic acid (AA)+GTE, 500 ppm
- C. Blend 154, 400 ppm
- D. Blend 124, 400 ppm

**Frying parameter**
- 2 kg oil/treatment
- 50 g noodles per cycle per treatment
- 80 frying cycles

**OSI of fresh oil (120 °C)**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>OSI (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>11.4</td>
</tr>
<tr>
<td>RE+AA+GTE</td>
<td>12.3</td>
</tr>
<tr>
<td>Blend 154</td>
<td>11.8</td>
</tr>
<tr>
<td>Blend 124</td>
<td>11.8</td>
</tr>
</tbody>
</table>

**OSI of Batch 40 oil (120 °C)**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>OSI (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>8.4</td>
</tr>
<tr>
<td>RE+AA+GTE</td>
<td>8.7</td>
</tr>
<tr>
<td>Blend 154</td>
<td>12.0</td>
</tr>
<tr>
<td>Blend 124</td>
<td>12.4</td>
</tr>
</tbody>
</table>

**OSI of Batch 80 oil (100 °C)**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>OSI (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>17.3</td>
</tr>
<tr>
<td>RE+AA+GTE</td>
<td>12.9</td>
</tr>
<tr>
<td>Blend 154</td>
<td>22.4</td>
</tr>
<tr>
<td>Blend 124</td>
<td>27.4</td>
</tr>
</tbody>
</table>
Total polar compounds

**Conclusion**

- Frying oil from Blend 124 and 154 treatments were more stable than others
- Blend 124 was most effective in decreasing the TPC of frying oils
Recommendation for frying oils

- Blends of LSGT, rosemary extract and mixed tocopherols is highly recommended for frying oils

- The ratio of LSGT/RE/MT is very critical to the anti-oxidative performance of AO blend

- Recommendation for frying soybean oil
  - Blend 123, > 300 ppm

- Recommendation for frying palm oil
  - Blend 124 (TRLG 101), > 400 ppm

Note: The dosage of Blend 123 and 124 can be adjusted based on customers’ demands
More about LSGT... ...

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Thanks