**�**

When adding antioxidant to oil, we observed that Vitamin E, vitamin A, and sesame seed oil dissolved in oil readily because they are oils themselves. Powdered rosemary dispersed and hung suspended in the oil, but did not dissolve. Green tea dispersed in the oil but then settled on the bottom of the jar. Ginger and garlic were chopped into fine pieces. When added to the oil, they settled on the bottom of the jar, as well as the crushed iron sulfate tablet.

Raw data was collected each day, and therefore, our [data tables](http://www.geocities.com/RainForest/4124/NSOdata.html) are arranged by day. See Tables 5 - 12 for our compiled data.

In concentration one, our target was to add approximately 0.01g of each antioxidant with 10.0g of soybean oil, or a 0.1% concentration. However, limited laboratory means prevented us from measuring exact quantities of antioxidant. (It is difficult to extract half a drop of vitamin E oil from a capsule.) While most samples did indeed have 0.01g of antioxidant, others went as high as having 0.03g of antioxidant, which would obviously lead to error in collecting data. The true concentrations of each antioxidant are shown in Table 1.

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**Table 1 � Concentration One of Antioxidant added to Soybean Oil**

|  |  |
| --- | --- |
| Antioxidant | % Added for Concentration One (~ 0.1%) |
| Vitamin A | 0.38 |
| Vitamin C | 0.136 |
| Ginger | 0.099 |
| Vitamin E | 0.4 |
| Garlic | 0.115 |
| Green Tea | 0.099 |
| Rosemary | 0.11 |
| Sesame Seed Oil | 0.209 |
| Iron Sulfate\* | 0.133 |

\* Iron Sulfate is not an antioxidant; it is a prooxidant meant to act as a negative control.

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After the first day of experimentation, no sample had developed an odor yet. By the second day, all samples had begun to develop an odor. The level period of smell, when the odor of the sample remains constant, is known as the induction period. A brief induction period is common for the oxidation of oils.

[Figure 1](http://www.geocities.com/RainForest/4124/NSOgraph.html) shows that the oil was most stable in the presence of rosemary in comparison with the other samples. However, the other antioxidants are too close for us to be able to determine the next most effective antioxidant. Without the addition of any antioxidant, control oxidized rapidly, compared to all other oils with antioxidants. The rancid odor in oil with iron sulfate developed more rapidly than that in other samples. This is due to the prooxidant characteristics of iron sulfate in oil oxidation. However, control displays a higher rate of oxidation than iron sulfate. The leveling of the graph for iron sulfate and control is due to the fact that our rubric ended at four. After this point, there was no higher score that could be given, and the human nose cannot distinguish between odors at such high levels as these. (This explanation can be applied to [Figures 2 and 3](http://www.geocities.com/RainForest/4124/NSOgraph.html) as well.)

The target concentration for concentration two was 0.05g of antioxidant per 10g of soybean oil, or a 0.5% concentration. The exact amounts of antioxidants added to oil for concentration two are shown below in Table 2.

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**Table 2 � Concentration Two of Antioxidant added to Soybean Oil**

|  |  |
| --- | --- |
| Antioxidant | % Added for Concentration Two (~ 0.5%) |
| Vitamin A | 1.2 |
| Vitamin C | 0.501 |
| Ginger | 0.716 |
| Vitamin E | 1.015 |
| Garlic | 0.577 |
| Green Tea | 0.519 |
| Rosemary | 0.505 |
| Sesame Seed Oil | 0.597 |
| Iron Sulfate\* | 0.631 |

\* Iron Sulfate is not an antioxidant; it is a prooxidant meant to act as a negative control.

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[Figure 2](http://www.geocities.com/RainForest/4124/NSOgraph.html) shows that rosemary is the most effective antioxidant at a 0.5% concentration. Iron sulfate catalyzes oxidation, and therefore had the highest rate of oxidation and no induction period. This higher concentration of iron sulfate promoted oxidation so much that its oxidation rate surpassed that of control.

The target concentration for concentration three was 0.1g of antioxidant per 10g of oil, a concentration of 1.0%. The actual amount of antioxidant added to oil for this concentration is shown in Table 3 below.

�

**Table 3 � Concentration Three of Antioxidant added to Soybean Oil**

|  |  |
| --- | --- |
| Antioxidant | % Added for Concentration Three (~ 1.0%) |
| Vitamin A | 1.114 |
| Vitamin C | 1.096 |
| Ginger | 1.363 |
| Vitamin E | 1.104 |
| Garlic | 1.062 |
| Green Tea | 1.032 |
| Rosemary | 1.034 |
| Sesame Seed Oil | 1.015 |
| Iron Sulfate\* | 1.021 |

\* Iron Sulfate is not an antioxidant; it is a prooxidant meant to act as a negative control.

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At this concentration, the same general trends are observed. Iron sulfate has the highest rate of rancidity development. The oil with rosemary displays the highest level of stability among all the other antioxidants. However, all antioxidants in this concentration were obviously less effective than their counterparts in other concentrations, as is shown in [Figure 3](http://www.geocities.com/RainForest/4124/NSOgraph.html). Together, the graphs in [Figures 1, 2, and 3](http://www.geocities.com/RainForest/4124/NSOgraph.html) generally show the same basic trendline as those found in published works of researchers.

In [Figure 4](http://www.geocities.com/RainForest/4124/NSOgraph.html), the results (odor) from T=5 for all three concentrations have been compared. There is no significant difference between concentrations one and two. However, concentration three no longer shows high antioxidant effectiveness. (Concentration three, 1.0%, is the highest concentration among those we tested.) The antioxidant effects of the samples seems so diminished by the high concentrations that there was an induction period for only three of the eight antioxidants. This idea can be further illustrated in [Figure 5](http://www.geocities.com/RainForest/4124/NSOgraph.html), where rosemary's sensory test results are graphed for all three concentrations. All rosemary concentrations shared the same induction period and results until T=2. After this time, concentration 1 and 2 results overlapped and remained close together. However, concentration three's results are substantially higher than the other two concentrations on all remaining days of experimentation. The rate of oxidation in oil for iron sulfate did increase consistently from lower concentrations to higher concentrations.

To qualify our data obtained by sensory testing, we decided to conduct a titration which could be used to find the peroxide value of a given sample. Peroxide value increases as oxidation progresses. However, due to the safety measures taken at school (the procedure required chloroform), we were unable to perform the titration concurrently with our sensory test.

Almost a week after our sensory tests had concluded, we found a substitute for chloroform: dodecane. Using this, we were able to perform the peroxide value test (titration) at T=12 days. By this time, we hadn�t expected to do any further experimentation, and several of our samples were no longer available. The results are shown below in Table 4.

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**Table 4 � Peroxide Value for Various Samples at T=12**

|  |  |
| --- | --- |
| Sample | Peroxide Value (meq.) |
| Fresh Oil\* | 0.4 meq. |
| Control | 22.2 meq. |
| Iron Sulfate Concentration 1 | 34.4 meq. |
| Rosemary Concentration 1 | 19.4 meq. |

\*This sample was fresh soybean oil kept at room temperature from T=0.

�Iron sulfate has the highest peroxide value, corresponding with our sensory data. Rosemary has the lowest peroxide value, as in our findings. The fresh oil peroxide value supports the validity of our other titrations because of its low number. These titration results support the data obtained from our sensory tests.

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[Graphs](http://www.geocities.com/RainForest/4124/NSOgraph.html) | [Data Tables](http://www.geocities.com/RainForest/4124/NSOdata.html) | [Conclusion](http://www.geocities.com/RainForest/4124/NSOconc.html) | [Recommendations](http://www.geocities.com/RainForest/4124/NSOrec.html) | [Bibliography](http://www.geocities.com/RainForest/4124/NSObib.html) | [Acknowledgements](http://www.geocities.com/RainForest/4124/NSOack.html)

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