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QUALITY OF OLIVE OILS AVAILABLE LOCALLY: CHEMICAL, SENSORY AND MARKET INVESTIGATIONS

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BY

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THESIS

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Abstract:

Olive oil is a high quality food that comes at a high-quality price. Extra virgin olive oils are obtained through specific methods created to extract the highest quality oil. The world market of olive oil is rife with accusations of adulteration and false claims regarding quality. These are serious accusations, since adulteration results in lower quality oils. True extra virgin olive oils contain higher levels of beneficial compounds including antioxidant phenolic compounds. Specific mechanisms have been identified in which phenolic compounds in the olive oil matrix exhibit antioxidant activity contributing to the prevention of cancer and cardiovascular disease, among other health benefits. The question investigated is; "How do olive oils available locally measure up in terms of phenolic compound content and flavor, and does this show in the way they are marketed?" Olive oils were obtained from locations around the University of New Hampshire and assessed for total phenolic content through colorimetric absorbance after extraction and reaction with Folin-Ciocalteu reagent. Three EVOO selected for their range of phenolic content were evaluated by sensory analysis. Analysis regarding the relationship between storage methods and container type, phenolic contents and Hedonic acceptance followed the sensory investigation. The results of the chemical analysis supported that olive oils vary greatly in the concentration of phenolic compounds; the sensory analysis showed a preference for olive oils with low to moderate levels of phenolic compounds. Comparing the market analysis of locally available olive oils resulted in the finding that price is not related to consumer preference or phenolic compound content level. To conclude, the researchers recommend more research be put into this effort, and consumers become more educated regarding the quality of olive oils.

Introduction

Mediterranean Diet

An obesogenic environment has developed in the United States over the past few decades, resulting in skyrocketing incidences of overweight and obesity (1). As a result, obesity-related disease rates are also increasing. Response to this has included recent scientific and anthropologic investigations into which diets best benefit the human body, so as to better educate the American people for future healthful choices. The Mediterranean diet has increased popularity recently. This is largely due to research findings that it is one of the most beneficial diets known for human health.REF (1)

Olive Oil

Olive oil has been a staple, both dietary and functional, in Mediterranean countries for thousands of years. The uses of olive oil in rituals, blessings and offerings are referenced throughout ancient texts, including the bible. More practically, olive oil has been used as an antiseptic, poison antidote, and fuel for lamps (2). In recent decades, additional Western countries have adopted olive oil into their cuisines based on its delightful flavors and ever expanding understanding of health benefits. As recently as February of 2013, the heart health benefits of the Mediterranean diet including generous helpings of olive oil have been documented in medicine and health (1).

The Mediterranean diet is studied extensively due to its purported disease-reducing powers (1) This diet is different from Western diets in that it involves the consumption of most fat from extra virgin olive oil (EVOO), fewer refined carbohydrates, moderate

amounts of lean proteins, moderate amounts of wine, and less saturated fats in comparison (1). Compositionally, it is noted for its high intake of monounsaturated fats and vitamins. It is a general pattern of eating that has been noted for promoting health in many different ways, including effects from cancer prevention to skin health (1). The Predimed study published in 2013 reported that the Mediterranean diet supplemented with olive oil or nuts reduces the incidence of cardiovascular disease by 30% in high risk individuals who exhibit risk factors for cardiovascular disease (1). Prevention has not yet been studied extensively. However, this study along with numerous others cited supports the fact that consuming olive oil may assist in preventing cardiovascular disease.

Studies have increasingly found that extra virgin olive oil, a main component of the Mediterranean diet, may be responsible for many of the health benefits associated with the diet (1, 3). Olive oil is made through the extraction of the oil from the fruit of the olive tree, *Olea europea L.* (4). Once extracted, the oil consists of two phases; a saponifiable phase, which includes triglycerides and comprises 98% of the olive oil, and an unsaponifiable aqueous phase, which includes the minor components of the olive oil (4). Though they are contained in the phase that makes up a mere 2% of the volume of olive oil, the minor components include many of the biologically important chemical compounds that are accountable for the health benefits attributed to olive oil (5).

Phenolic Compounds

The minor components of the aqueous phase of olive oil include phenolic compounds, which have been noted for radical scavenging and are responsible for many of the apparent health benefits of olive oil (1, 4-6). Extra virgin olive oil, extracted during the first press of the olive fruit, contains the highest amounts of phenolic compounds. During refining processes for other grades of olive oils of lesser purity, levels of phenolic compounds are reduced or eliminated completely. Extra virgin olive oil is the richest source of phenolic compounds in regards to vegetable oils (7).

Phenolic compounds consist of one basic aromatic ring with a hydroxyl group attached (see *Figure 1* below). They can be integrated with one another in any number of ways, and can include conjugated side groups that may alter their activities or bioavailability and absorption within the body. Phenolic compounds made of two or more phenols are called 'polyphenols'. Phenolic compounds are chemically notable because they act as antioxidants. Reactive oxygen species (ROS) are generated throughout physiology through common cellular mechanisms in the body such as cellular respiration. When these mechanisms cause production of ROS that outnumber antioxidants, oxidative stress occurs. Oxidative stress causes damage to deoxyribonucleic acid (DNA), proteins, lipids and other essential molecules through various mechanisms (8). Similar damage may also occur with external exposure to harmful substances such as carcinogens, and failure of normal body defense functions (9). Higher levels of oxidation have been linked to an increased risk of many pathological manifestations, including degeneration of the arterial endothelium and peripheral nerve damage (7-9). The basic mechanism of accepting an

electron is the foundation for many of the health-related functions that have been attributed to phenolic compounds (8, 10).

***Figure 1*. Examples of phenolic compounds contained in olive oils**

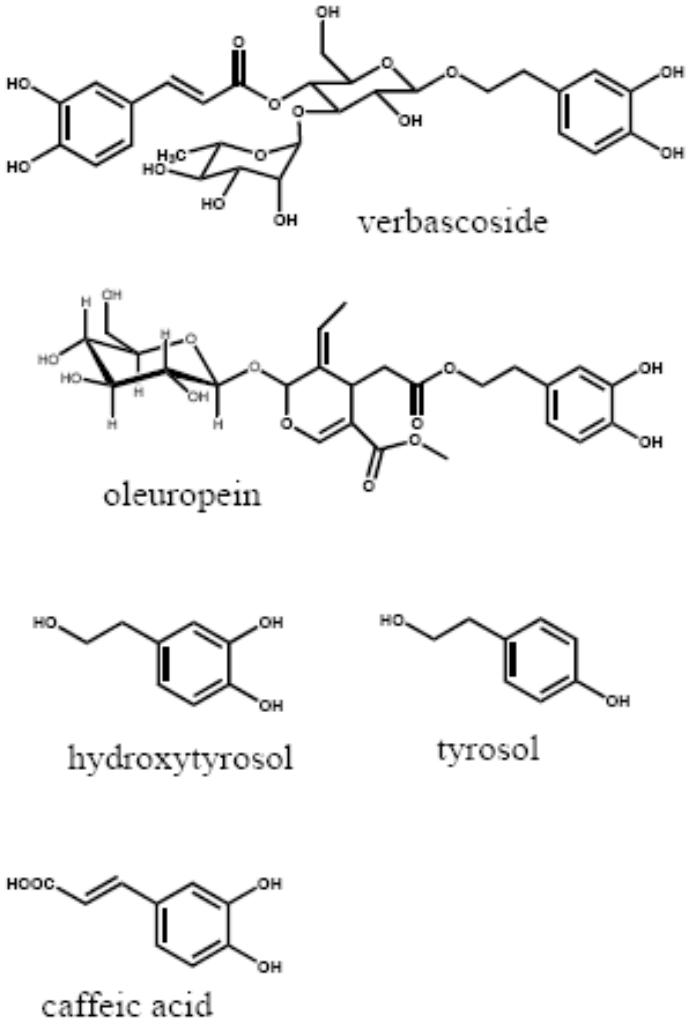

Figure 1: examples of phenolic compounds commonly found in olive oil. Phenolic compounds range from small to large and the functional group is a hydroxyl group conjugated to an aromatic ring. (11)

Extra-virgin olive oil has been attributed to reducing the risk of and mitigating symptoms of various diseases and pathologies (12-19). One of the most-studied diseases in relation to the Mediterranean diet and phenolic compounds is cardiovascular disease. A Mediterranean diet enriched with olive oil was found to reduce the risk of cardiovascular disease in high risk individuals by 30% (1) The effect of extra virgin olive oil on the pathology of cardiovascular disease and its many components has been studied extensively to uncover the mechanisms behind its preventative and alleviant effects on these diseases. However, many of the mechanisms and explanations still remain mysterious to researchers, requiring years more of research to investigate.

Extra Virgin

Extra virgin olive oil (EVOO) is considered the highest quality of olive oil. It results from the first, mechanical pressing of the olives at a cool temperature, called the "first cold press". This press of the olives produces an olive oil containing chemical and organoleptic qualities according to standards established by the International Olive Council. An olive oil of high quality that is stored appropriately presents the freshest taste and is considered to contribute the highest benefit to human health out of all grades of olive oils. This oil also contains the highest concentration of phenolic compounds (20).

The expanded interest in olive oil of recent years has led to an increase in the market size and increased adulteration of the products in the market in order to cut costs. Such adulteration has been discovered in many olive oils being imported into the United States (21). The main adulteration technique involves adding a small amount of extra virgin

olive oil to a large batch of chemically extracted olive oil and marketing it as extra-virgin olive oil at the expected high price for premium oil. This adulteration elicits much concern due to the fact that following the first cold press, olive oils are lower in grade, contain lower amounts of antioxidants, and are of inferior sensory quality. From a nutritional standpoint, the later extractions of oils from olives contain less of the superior health components of olive oil, including (but not solely) phenolic compounds (21). From a gastronome's perspective, after the first cold press, the oil simple does not taste as good. Few studies have been conducted to find out what percentage of olive oils are mislabeled.

Researchers at the University of California at Davis have investigated the chemical composition and sensory quality of imported olive oils to find out whether the olive oils being sold on grocers' shelves meet the standards set by the International Olive Council (21). Another reason for concern in the olive oil sector is that the quality of olive oil is affected by storage methods and time. Heat, light and time all negatively affect olive oil quality, including levels of phenolic compounds, thus making the olive oil less healthy and reducing its organoleptic qualities (22).

The focus of this research was the assessment of the quality standard of locally sold olive oils. Concern surrounding this issue of quality is growing, but action is not being taken quickly enough for those who feel it is a serious problem. As research on the health benefits of the Mediterranean diet continues to focus on olive oil, it is important for consumers to know whether they are purchasing what is being marketed to them. Olive oil is a commodity that consumers are willing to pay a higher premium for- both because of its unique organoleptic qualities and for its well-promoted promoted health benefits.

Objectives

1. To analyze the levels of total phenolic compounds in ten samples of olive oils from local grocery stores.

2. To investigate the relationship between flavor and phenolic compounds from a consumer perspective.

3. To relate the sensory properties and phenolic compound contents to the marketing of the olive oils.

Hypotheses

1. Olive oils marketed similarly will not be of similar organoleptic appeal to a representative consumer population.

2. The levels of phenolic compounds in the olive oils will vary greatly. Pricier olive oils and oils stored in dark green glass bottles will contain higher amounts of phenolic compounds.

3. Olive oils containing lower to moderate amounts of phenolic compounds will be preferred by the consumer taste panel.

Materials and Methods

Selection of Olive Oils

Ten olive oils produced by independent companies were purchased from Hannaford (Raymond, New Hampshire) and Walmart (Hooksett, New Hampshire). These choices were made with the aim of emulating a sample of olive oils that are available for purchase by the average consumer looking to buy quality olive oil while shopping at their local grocery store. The olive oils were analyzed in three ways. Firstly, a chemical analysis for the concentration of total phenolic compounds was performed. Next, a sensory analysis was conducted. Lastly, a market analysis was carried out and expanded to include other brands of olive oils available locally.

Chemical Methods

Total phenolic compounds were measured in a food science lab using the Folin-Ciocalteu method (23). 2.5 grams of each olive oil were measured in duplicate on a Mettler AM50 scale and mixed with 5 mL of hexane in a test tube. To this mixture was added 3 mL of a 60:40 MeOH in water solution. The resulting solution was vortexed for two minutes using a Fisher Vortex Genie 2. They were then centrifuged in an Eppendorf Centrifuge 5804R 15 amp version for 10 minutes at 3500 RPMs at 20^0C. This resulted in a separation of the aqueous and lipid layers. The aqueous component was removed, and to the lipid layer was added 3 more mL of the 60:40 methanol in water solution. The process of vortexing and centrifugation was repeated, and the aqueous layer was again removed. The two aqueous layers were combined. The Folin-Ciocalteu method required a 200 uL aliquot of the aqueous extraction placed in a separate test tube. This was diluted

to 2.5 mL with Millipore MilliQ type 1 Ultrapure water. 0.25 mL of Sigma Aldrich Folin & Ciocalteu's phenol reagent was added to this solution. After 3 minutes, .5 mL of an Aldrich 35% sodium carbonate anhydrous powder in water solution was added. The solution was diluted with water to 5 mL. Two hours later, a sample of each solution was measured for spectrophotometric absorbancy at a 725 nm wavelength.

Taste Test

Three olive oils were selected for the taste test. The olive oils are listed below. These oils were selected because of their representative phenolic compound content. Colavita exhibited the highest phenolic compound content when analyzed, Nature's Place had the lowest level out of all of the olive oils tested, and My Essentials Extra Virgin Olive Oil was the approximate middle of the range, containing a median amount of phenolic compounds compared to all of the other brands tested.

Approval for the use of human subjects was acquired from the University of New Hampshire Institutional Review Board to ensure the safety of all participants. The sensory analysis was conducted using a convenient sample of student volunteers
who had minimal tasting experience, thus emulating a general audience of consumers. The subjects were asked to voluntarily participate in the study, which took less than 5 minutes of their time after class. They were given an informed consent form to sign, and an evaluation sheet (see *Figure 2* below). Each participant took one of each of three numbered sample cups of olive oil. They tasted each olive oil, and could choose to do so with or without bread for dipping. They then responded to a number of questions on the prepared sensory evaluation sheet. These questions involved a Hedonic rating of pleasure

for each individual olive oil, a ranking of each olive oil in order from favorite to least favorite, and the option to circle adjectives for each olive oil. The participants were provided with a glossary describing the available adjectives for clarification.

Table 1: **Olive Oils Examined In Sensory Analysis**

Brand	Phenolic Compound Content (mg/mL)
Colavita	0.058
My Essentials Hannaford brand	0.033
Nature's Place Organic Hannaford Brand	0.017

Table 1 describes the olive oils used in the sensory analyses aspect of the study. Particular olive oils were chosen because of their respresentative content of phenolic compounds. Colavita had the highest amount, My Essentials had a moderate amount, and Nature's Place Organic had the least phenolic compounds of all the olive oils tested. These were chosen to highlight the flavor difference the amount of phenolic compounds can make in an extra virgin olive oil.

Figure 2: **Sensory analysis response sheet example**

Olive Oil Sensory Analysis

129: Rate olive oil 129 on a scale of 1-9

(Dislike)1--------2-------3-------4-------5-------6-------7-------8------9 (Like)

Circle the terms that you notice in olive oil 129. You can circle as many or as few as you notice.

Positive		
Fruity	Floral	Peach
Bitter	Forest	Peppery
Pungent	Fresh	Pungent
Apple	Grassy	Round
Almond	Green	Spice
Artichoke	Green tea	Sweet
Astringent	Hay	Tropical
Banana	Herbaceous	Tomato
Bitter	Nutty	Woody
Buttery	Mint	Eucalyptus

Negative		
Fusty	Muddy	Burnt
Musty	Metallic	Acetone
Winey/vinegary	Rancid	Blue cheese
Bacon	Dirty	Hay-wood
Burnt	Bland	Rough
Cucumber	Wet wood	Yeasty

Please rank the 3 olive oils from 1 to 3, with 1 being the one you liked the most and 3 being the one you liked the least.

1._____

2._____

3._____

Figure 2: An example of the page used for sensory analysis of the three olive oils previously described. For each olive oil, tasters were given a Hedonic scale to rate their liking of the olive oil from 1 (dislike) to 9 (like). They were given a box of positive and a box of negative terms to circle, with a glossary for reference (not pictured). Lastly, after tasting all three of the oils, participants were asked to rank them in order of preference, with 1 (one) being the most liked oil, and 3 (three) being the least liked oil, comparatively.

Market Analysis

The market analysis included Internet research, price gathering, and label examination at the stores. The information was recorded, synthesized and eventually used to draw conclusions with the results of the chemical analysis and the sensory analysis (see *Figure 6).*

Results

Chemical Analysis

The analysis was performed as described above. The reference curve for phenolic content was constructed using Sigma C0625 caffeic acid treated with the same procedures described above for the olive oils and diluted with methanol at the following concentrations.

Table 2: **Caffeic acid reference curve values**

[mg/mL]	Absorbance (725nm)
0.25	0.343+/-
0.125	0.155
0.0625	0.079
0.0312	0.031
0.0156	0.009
0.0078125	0.003

The curve constructed from these values was linear, with an R^2 value of 0.9986.

Figure 3. **Caffeic acid standard curve**

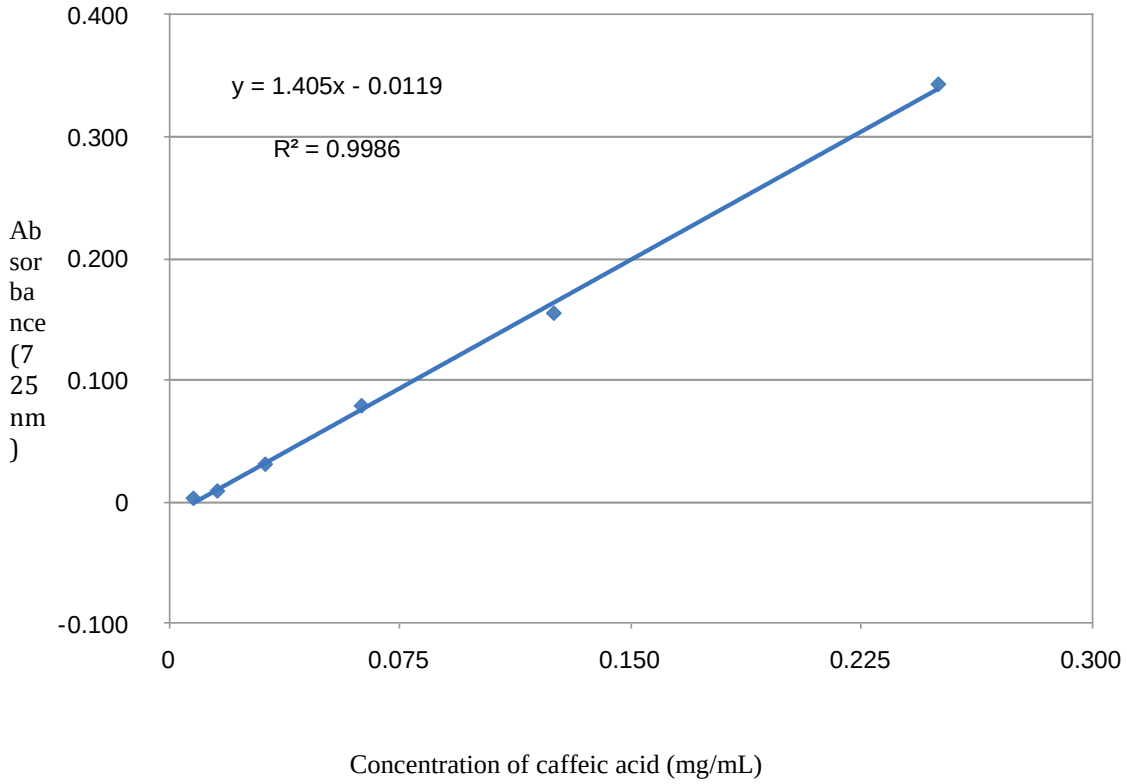

Figure 2 shows the standard curve of caffeic acid constructed using various concentrations of caffeic acid in mg/mL, displayed on the X axis, vs. the resulting spectrophotometric absorbance at 725 nm.

Once the absorbance of each olive oil was measured, the absorbance was factored into the equation for the curve, and the resulting number was accepted as a concentration of phenolic compounds in milligrams per milliliter of the olive oil. The results of the analysis for phenolic compounds can be found in *Figure 4* below.

***Figure* 4. Chemical analysis results by brand**

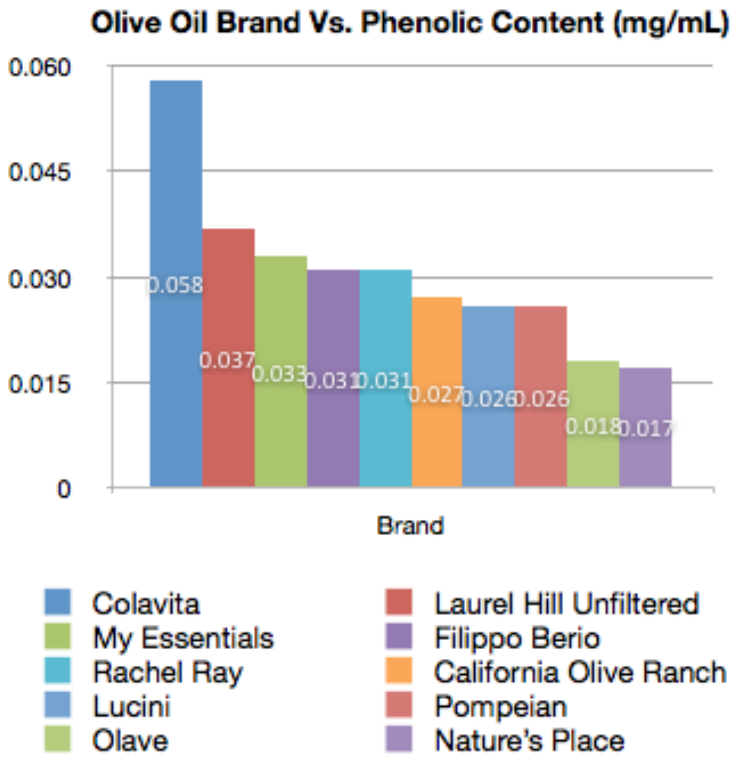

Figure 4 displays the information from the sensory analysis of phenolic compound content in ten difference olive oils. The X axis shows the various brands, while the Y axis shows the amount of phenolic compounds in each of the olive oils.

As can be seen from the chart, the brand that exhibited the highest content of phenolic compounds in mg/mL is Colavita. The brand with the lowest amount of phenolic compounds was Hannaford's organic brand, Nature's Place. The amounts of phenolic compounds ranged from 0.017 mg/mL of olive oil to 0.058 mg/mL of olive oil. This is a three-fold difference between the lowest and highest amounts- quite a significant difference. The possible reasons for this will be touched upon in the discussion section.

Sensory Analysis

Twenty-one participants took part in the sensory analysis. Each signed the consent form and submitted it to the researchers to be kept on file for three years. The tasting went as planned. Each olive oil was placed in a clear tasting cup with a three digit number based on the brand (129, 767, and 942) on the cover. Each participant took one sample of each olive oil to taste. Some participants used bread as well as sipping to taste the olive oil, while others tasted it straight from the tasting cup. Many participants used the glossary of terms provided in order to understand the terms they were circling.

The results of the sensory analysis are detailed in the chart below. As can be clearly seen, participants ranked the Nature's Place™ olive oil as the preferred olive oil of the three using the scale of 1 through 9, with 1 being disliked and 9 being liked. They most commonly described this olive oil as "buttery" and "sweet". They most commonly described the Colavita™ olive oil as peppery and pungent. Participants liked the Colavita least of the three. My Essentials™ olive oil was often described as bland, buttery and grassy.

Figure 5. **Hedonic scale ratings of 3 olive oils from sensory analysis**

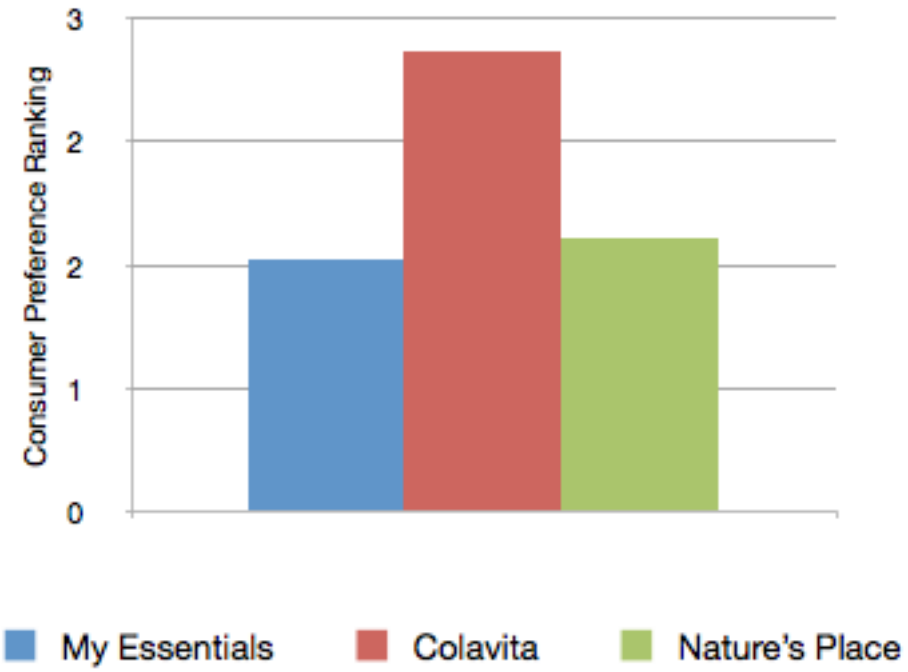

Figure 5 shows the preference rankings of the consumer panel during the sensory analysis. In this case, consumers ranked the olive oil they preferred least the highest. Therefore, Colavita was liked the least whereas My Essentials was the most-liked olive oil. My Essentials contained a moderate amount of phenolic compounds in the chemical analysis.

Market Analysis

Similar brands of EVOO are available at local stores, with store brands costing an average of $0.15 less per ounce than the highest priced olive oil. The local Hannaford and Walmart Stores carried similar brands with only 3-4 variations. The quantity and quality of information presented on olive oil bottles, the style of bottles, and the claims made on each bottle varied widely.

In general, the more expensive olive oils were presented with a "rustic" label. This involved the display of a brown or green paper label, the mention of the country in which the olive oil was made, and a short explanation of why the olive oil is high quality. Many of the bottles also displayed serving suggestions, such as My Essentials Extra virgin olive oil, which reads "great for dipping & salad dressings" on the label. My Essentials is also rated three stars under the "Guiding Stars" system that Hannaford has introduced, with the three stars rating suggesting it is the healthiest choice of oils (24).

Discussion

Chemical Analysis

The results of the chemical analysis were both interesting and different than expected. The levels of phenolic compounds in different olive oils varied greatly. The explanation for the difference does not lie in one specific answer. In contrast, there are many factors that can change this chemical property of an olive oil. The phenolic compound contents of olive oils are impossible for a researcher to completely understand unless the creation of olive oil is followed from the planting of the olive tree until the olive oil is bottled and stored. Examples of variables that can affect the levels of phenolic compounds in extra virgin olive oils include, but are not limited to:

- Climate and cultivar the olive grove is in. However, most olive oils are composed of olive from many different countries. Because of this, it is impossible to predict the levels of phenolic compounds based on location.
- Age of the olives when they are picked and pressed.
- Time of the year in which the olives are harvested.

- Age of the olive oil. Phenolic compounds are antioxidants. As free radicals are produced within the olive oil, phenolic compounds will be consumed.
- The storage method of the olive oil. This involves the type of bottle (glass or plastic), the color of the bottle, the lighting and temperature in which the oil is stored (2).

As can be told from this minimal list of variables, it is not easy to tell why phenolic compound levels in certain oils are as such. However, it is important to keep in mind that an olive oil that is harvested and pressed correctly, unadulterated, and stored in the appropriate settings according to the International Olive Oil Council will contain a higher amount of phenolic compounds than an olive oil that is not correctly processed and stored (4, 25).

Sensory Analysis

The olive oils analyzed by the tasting panel were in line with the hypotheses formulated: that the tasters would prefer some olives oils over other olive oils, and that they would prefer the olive oils with less phenolic compounds. This is interesting and important to consider, since the olive oils with higher amounts of phenolic compounds contain more health-promoting compounds, including phenolic compounds. Phenolic compounds do impart a peppery, more intensely sharp flavor to the olive oils, and Americans are most likely used to oil as a background flavor, a vehicle for other flavors rather than a flavor of its own. More research should be done in this sector to better understand what makes an olive oil preferable to the population of general consumers.

Market Analysis

Olive oil is aggressively marketed throughout the world, and especially throughout America as a common ingredient promoting health and good taste. According to the research carried out over the past few months, there is no direct information conveying to consumers that olive oils from different cultivars, produced differently, or stored well or not will contain different health benefits or sensory value. This is an issue that might benefit by being addressed. The wine market thrives because of the clear delineation of value that is conveyed in different wines. High quality wine is a widely sought after and respected commodity. The olive oil market may benefit from similar marketing techniques. It is from the sensory analysis that olive oils taste differently based on various factors.

The website www.Oliveoiltimes.org is dedicated to the promotion of extra virgin olive oil. The creators of the website publish information about the creation of olive oil, the importance of it in daily life, and the reasons it is crucial to a healthful diet. An entire tab is dedicated to the health benefits of olive oil. An example of an article promoting the compounds contained in olive oil was recently published in August 2013. Its title, "Extra Virgin Olive Oil May Prevent Alzheimer's Disease" does not suggest that any extra virgin olive oil is better at promoting this than others (26). It simply states that extra virgin olive oil can prevent Alzheimer's disease. However, as discussed in the previous section, consumers prefer an olive oil that contains less of these phenolic compounds that may reduce the risk of Alzheimer's disease.

Figure 6: **Comparison of olive oils in three categories: price per ounce, phenolic content, consumer preference ranking.**

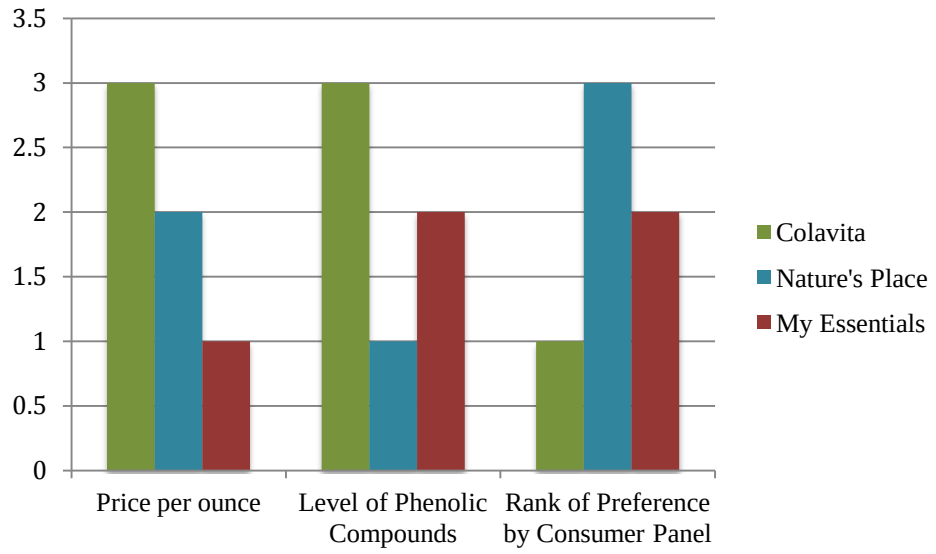

Figure 6 shows the relationship between price, phenolic content, and consumer ranking through ranking. Each oil is ranked from 1 to 3 on each scale. Price- 1 is the lowest, 3 is the highest. Level of phenolic compounds- 1 is the least, 3 is the most. Rank of preference by consumer panel- 1 is the least liked, 3 is the most. As can be seen, there is no correlation between any of these three traits of olive oils according to this research.

Conclusions

Currently olive oil sells for about $13 USD per gallon . That is about 3.7 times the price of a gallon of rapeseed oil, which sells for about $3.50 USD per gallon (27). Olive oil is not a cheap commodity. It is marketed as a high class, health promoting and delicious product that consumers should feel is worth the money they spend on it. However, recent studies have questioned whether consumers are truly getting what they are paying for when they purchase olive oil off the supermarket shelves. Adulteration, inappropriate storage techniques, rancidity- these are all very real concerns from the consumer and nutrition perspectives.

During this study, no conclusions could be drawn regarding the quality of the olive oils studied, as a non-professional tasting panel was used, and the only chemical aspect of the olive oil studied was the phenolic content. However, this study did reliably find that phenolic content in various olive oil brands does tend to vary greatly based on brand. This study also was able to determine that the average consumer prefers olive oil containing less phenolic compounds rather than more, which conflicts with the fact that greater amounts of phenolic compounds promote more effective health benefits.

Suggestions for future studies

- If antioxidant content is lower in olive oils that consumers prefer, the main marketing technique for olive oils should not be the antioxidant qualities that they have within the body.
- Olive oils from different regions of the world contain various amounts of phenolic compounds, which translates to various health benefits. If this could be labeled on the bottle, consumers would be aware of what they were purchasing, and use their purchasing power to determine which olive oils they would like to see on the shelf.
- An analysis in greater depth of the market success of each olive oil. This could be further analyzed using demographics of consumers based on brand.

In conclusion, the hypotheses formulated for this investigation into local olive oils were accepted, and the researchers can safely conclude that the chemical and sensory qualities

of olive oils available for sale in southeastern New Hampshire vary considerably, while all extra virgin olive oils are apparently marketed as equals in terms of flavor and beneficial components. More research into the differing qualities and varieties of extra virgin olive oils may conclude that consumer awareness of variations in qualities of olive oils would produce an educated consumer and a more competitive market with a higher standard for quality.

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Appendix

Figure A1: Chemical Analysis Results

	Total Phenolic Compound Content		
Sample	**Absorbance (725 nm)**	**Avg. Absorbance**	**[mg/mL]**
Colavita	0.075	0.0695	0.058
	0.064		
My Essentials	0.033	0.0345	0.033
	0.036		
Filippo Berio	0.031	0.0315	0.031
	0.032		
Pompeian	0.023	0.024	0.026
	0.025		
Laurel Hill Unfiltered	0.029	0.0395	0.037
	0.050		
California Olive Ranch	0.024	0.0265	0.027
	0.029		
Olave	0.017	0.0135	0.018
	0.010		
Nature's Place	0.009	0.0125	0.017
	0.016		
Lucini	0.023	0.0245	0.026
	0.026		
Rachel Ray	0.033	0.032	0.031
	0.031		

Figure A2: Sensory Analysis Adjective Results

	My Essentials	Colavita	Nature's Place
Positive			
Fruity	3	0	2
Bitter	1	6	3
Pungent	2	5	3
Apple	1	0	0
Almond	0	0	1
Artichoke	0	0	0
Astringent	0	1	0
Banana	0	0	1
Buttery	7	3	7
Floral	3	0	1
Forest	0	0	0
Fresh	6	0	2
Grassy	4	4	3
Green	4	2	2
Green Tea	2	0	0
Hay	1	1	0
Herbaceous	3	0	0
Nutty	2	1	2
Mint	0	0	0
Peach	0	0	0
Peppery	1	4	0
Round	2	0	2
Spice	1	5	4
Sweet	1	0	3
Tropical	1	0	0
Tomato	1	0	0
Woody	0	2	1
Eucalyptus	0	0	0
Negative			
Fusty	0	0	0
Musty	1	3	1
Winey/Vinegary	0	2	0
Bacon	0	0	0
Burnt	0	1	0
Cucumber	0	0	1
Muddy	0	1	0
Metallic	0	1	0
Rancid	0	1	0
Dirty	0	0	0

Bland	2	3	2
Wet Wood	0	1	1
Burnt	0	1	0
Acetone	0	1	0
Blue Cheese	0	0	0
Hay-wood	0	0	0
Rough	0	1	0
Yeasty	0	0	0

Figure A3: Sensory Analysis Olive Oil Ranking Results

My Essentials	***Colavita***	***Nature's Place***
1	3	2
2	3	1
2	3	1
2	3	1
2	3	1
2	3	1
1	2	3
1	3	2
2	3	1
3	2	1
1	3	2
1	2	3
1	3	2
1	3	2
1	3	2
1.53333333	*2.8*	*1.666*

Figure A4: Market Analysis of Olive Oils Available Locally

Brand	*Name*	*Title*	*Claims*	*Price/oz.*	*Source(s)*
Pompeian	Extra Virgin Olive oil	First cold press	Robust flavor, imported	0.31	N/A
Rachael Ray	Everyday EVOO		Packed in Italy, first cold pressed	0.58	N/A
Filippo Berio	Organic Extra Virgin Olive Oil	Organic	Imported from Italy, all natural cold pressed	0.39	Italy, Spain, Tunisia
My Essentials	100% pure Extra Virgin Olive Oil		3 guiding stars (Hannaford brand)	0.29	Italy, Spain, Tunisia, Turkey, Morocco, Argentina
Botticelli	Extra Virgin Olive Oil	Premium	Cold pressed	0.35	Italy, Spain
Taste of Inspirations	Extra Virgin Olive Oil	Imported Greek	100% all natural, first cold press	0.47	Greece
Taste of Inspirations	Extra Virgin OliveOoil	Imported Spanish	100% all natural, first cold press	0.47	Spain
Taste of Inspirations	Extra Virgin Olive Oil	California	100% all natural, first cold press	0.47	USA
Carapelli Florence	Extra Virgin Olive Oil		First cold pressing, premium 100% Italian	0.52	Italy
Bertolli	Extra Virgin Olive Oil		Rich Taste, imported from Italy	0.44	Italy, Spain, Greece, Tunisia
Colavita	Extra Virgin Olive Oil	Cold-Pressed	Certified authentic, first cold pressed	0.57	Italy
Nature's Place	Extra Virgin Olive Oil	Nature's Place	USDA Organic	0.44	Argentina, Italy, Tunisia