DFM 357: Experimental Foods

Virgin Coconut Oil as a Substitute for Butter in Baking

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12/14/2012

Abstract

Virgin Coconut Oil (VCO), although saturated, is a cholesterol-free fat that can be used in place of traditional fats such as butter in baking. Current research suggests that VCO, when used in place of saturated fats of animal origin, can lower total cholesterol and increase both insulin sensitivity and immunity. These benefits make VCO a promising alternative to butter for populations which require low cholesterol diets. We substituted VCO in place of butter in a Mrs. Fields Chocolate Chip Coconut Macadamia Nut cookie recipe in order to test changes in and acceptability of flavor, texture and appearance. Three types of cookies were prepared with either butter, VCO or a combination of both. Twenty –five tasters with no knowledge of these changes were recruited to sample the cookies. The results of our experiment indicate that people slightly prefer cookies made with butter in comparison to cookies made with VCO.

Introduction and Purpose:

According to epidemiological and clinical studies, elevated cholesterol levels are correlated with coronary heart disease (Nevin and Rajamohan, 2004, p.1). Nutrition experts and medical professionals have strongly recommended that a diet low in fat and cholesterol can reduce the chance of developing hypertension, atherosclerosis and heart attack and patients exhibiting these symptoms are often advised to limit their intake of animal fats. Animal fats are naturally high in saturated fat and cholesterol and contribute to increased serum cholesterol levels. Butter, for example contains 31 mg of cholesterol per tablespoon (McWilliams, 2012, p 259). While, saturated fats are also found in tropical oils such as coconut oil, they may be preferential to fats like butter because they contain no cholesterol.

Coconut oil has been the main source of dietary fat in countries around the world such as Sri Lanka, Philippines, and India (Enig, 2010). It has recently become a popular choice for American consumers. The health benefits attributed to coconut oil include lowered cholesterol and increased insulin sensitivity, however ingestion of coconut oil is controversial because of the oil's high degree

of saturation. Current research is reexamining saturated fat's effect on heart health and suggests that shorter chain fatty acids, like those in coconut oil, are metabolized differently than the fatty acids contained in butter or lard. We propose that substituting virgin coconut oil for butter could be a healthy and beneficial option for populations diagnosed with hypertension and high cholesterol. We designed an experiment to test the acceptability of using virgin coconut oil, a cholesterol free fat, in place of butter in Coconut Chocolate Chip Macadamia Nut Cookies.

Review of Literature:

Saturated fats are solid at room temperature and have chains comprised of carbon atoms linked by single bonds. Typically, saturated fats used in baking come from animal sources (lard, butter); however coconut oil is popular with vegans and others who avoid animal foods. Current research is examining how the number of carbons making up a fatty acid chain can affect health and metabolism. For example, coconut oil consists of approximately 62% of medium chain fatty acids (MCFA's) whereas other saturated fats, such as butter, contain long chain fatty acids (LCFA's). MCFA's are composed of fatty acids with chain lengths of 8-14 carbons (Ceylon) denoted Cn, with n being the number of carbons. The main constituents of Coconut Oil are lauric (C12) acid, myristic (C14), and capric acids (C10).

MCFA's do not get metabolized in the same way as LCFAs, which are packaged into chylomicrons and bypass the liver via the lymphatic system where they are delivered to tissues and stored in adipose tissue for later use (Labarthe, Belinas and Rosiers, 2008, p.4). MCFA's are water soluble when eaten and are delivered to the liver immediately. In cellular metabolism, MCFAs are able to enter the mitochondrial matrix at a rate governed by their concentration which allows the cell to use MCFAs as energy right away (Labarthe, Belinas and Rosiers, 2008, p.4). This type of metabolism has many benefits and clinical applications.

Medium Chain triglycerides (MCT's) or MCFA's, have been used for over fifty years in treating those with metabolic disorders, undernourished patients, and patient populations where

eating or retaining weight is a problem (Labarthe, 2008), such as Cystic Fibrosis or cancer patients. However numerous studies and articles suggest that MCFA s may also decrease LDL oxidation, increase HDL cholesterol and improve insulin sensitivity, as well as support immune function.

A study performed earlier this year found that medium chain fatty acids, particularly fatty acids with ten carbons (capric acid), bind to a nuclear hormone receptor called PPAR-y. This receptor is also the target site for thiazolidinediones (TZDs), a class of drugs that includes Metformin and is used to increase insulin sensitivity in type 2 Diabetics. TZDs are also used to reduce inflammation in the arteries but may increase fluid retention, fat accumulation and deposition, and risk for heart failure (Liberato et al, 2012).

When TZDs bind to PPAR-y, they alter and stabilize its conformation allowing for specific DNA response elements to modulate transcription of nearby genes. This alteration inhibits the enzyme activity of Cdk5 and decreases the expression of adipokines, which are cytokines produced by adipose cells. Medium Chain Fatty Acids can bind to these same receptor sites causing the same stabilization and altered gene expression. The result is increased insulin sensitivity without the side effects caused by TZDs. The study stated, "Diets containing decanoic acid improve insulin sensitivity in animal models. It is also known that dietary MCFAS are abundant in certain foodstuffs, particularly milk, coconut and palm oil and dietary supplementation of these compounds improves aspects of metabolic syndrome," (Liberato et al, p6). However the authors acknowledged that it is unknown whether dietary MCFA intake would be able to reach sufficient concentrations required to modulate PPAR-y.

In addition to increased insulin sensitivity, Virgin coconut oil was found to have beneficial effects on lipid levels in serum and tissues. In a study performed in India in 2004, 45 Sprague-Dawley rats were fed diets of ground nut oil, coconut oil or virgin coconut oil (VCO). At the end of the 45 day trial, the rats were sacrificed and their blood, liver and heart were examined. Those fed with VCO had significant decreases in serum, liver, heart and kidney levels of total cholesterol,

triglycerides and phospholipids. HDL cholesterol in CVO fed rats was also increased compared to the other groups. The authors of this study attribute these benefits to the higher concentrations of polyphenols in VCO and the way in which VCO is metabolized. They conjecture that VCO may influence the rate of synthesis and oxidation of fatty acids in the liver by inhibiting the activity of HMG CoA, the rate limiting enzyme for cholesterol synthesis (Nevin and Rajamohan, 2004, p. 3).

There also seems to be differences in the benefits supplied by industrial grade coconut oil, referred to as RBD coconut oil (Marina et al, 2009, p. 3) and VCO. RBD coconut oil is obtained via dry processing methods and is widely used. Dried coconut (copra) is cleaned, ground, and steamed then pressed to obtain oil. The oil is then refined, bleached and deodorized which involves the application of heat at temperatures of 204-245 C. This process changes the structure of the fatty acids; increases rancidity and can nullify coconut oil's antioxidant properties. VCO is obtained via wet processing which is devoid of bleaching, deodorizing or refining, thus leaving its fatty acids intact. In wet processing, coconut oil is extracted from the cream of fresh coconut milk without chemical or heat treatment (Marina et al, 2009, p. 1).

While the chemical composition of coconut oil proves to contribute to many positive health benefits, it also has interesting antimicrobial properties that have shown to increase immunity against certain pathogenic microorganisms. Coconut contains large amounts of lauric acid which turns into monoglycerides when consumed. Monolaurin, a derivative of lauric acid, has been shown to disrupt the lipid membrane of inactivated microorganisms such as bacteria, yeast, fungi and enveloped viruses (Enig, 2010). Researchers believe that because coconut oil is a lipid, it may be able to penetrate the lipid bilayer of a virus thereby killing it (Chomchalow, 2011). Current research is being conducted to measure the effect coconut oil has against new strains of HIV.

Lauric acid is also present in breast milk. Nearly 18% of breast milk is comprised of lauric acid is and this is believed to be why breast milk provides immunity against pathogenic microorganisms for babies who have not yet developed their immune system (Chomchalow,

2011). The consumption of lauric acid then may be beneficial for populations who have weaker immune systems, such as the elderly population.

Methods/Design

We chose to prepare a chocolate chip macadamia and coconut cookie recipe, where the type of fat being used was the independent variable. The control sample was prepared using butter, while the experimental (extreme) sample was prepared using 100% virgin coconut oil (VCO) in place of butter. We also prepared a third sample, which contained 50% butter, and 50% VCO. Various "mock trial" runs measuring taste and texture were conducted prior to a public tasting trial.

Prior to preparing all 3 samples, a standardized recipe was retrieved from Mrs. Field's cookie recipe collection (see Appendix A). Next, the ingredients listed in household measurements were converted to weight measurements (oz) for accuracy by the use of a standard ingredient to weight conversion chart (see Appendix A). These weights were divided by three and measured using an electronic scale, so that three samples could be prepared using one recipe batch.

In each of the three samples, the fat content and sugar were creamed for about 2 minutes on high with an electric mixer. Next the wet ingredients were added to the mixture and combined on high for 1 minute. Then the dry ingredients were incorporated into the mixture with the mixer on low speed for 30 seconds. Finally, it took roughly five hand strokes to fold in the macadamia nut, chocolate chips, and shredded coconut into the batter.

We conducted four "mock trials" prior to the public tasting in order to measure acceptability, flavor differences and textural differences (see notes in Appendix A). We also conducted objective tests to examine the physical properties of our cookies, such as spreadability and wettability. The line-spread test was conducted for both raw and baked cookies. Room temperature and refrigerated dough were also compared. We placed 0.7oz balls of each raw cookie dough sample on a paper containing a grid. Then, a 10"x10" square piece of glass was pressed down on each ball for 5

seconds with equal pressure. The diameter of the raw cookie dough was measured and recorded (Figure 2 in Appendix A).

Wettability is a test used to measure the moisture content in baked products. We conducted the wettability test by weighing each baked sample prior to submerging it in water for 5 seconds. The sample was then re-weighed. Its original weight was then subtracted from its post-soak weight and the difference was used to determine which cookie was the most moist (see figure 3 in Appendix A).

Two days before the public tasting, each type of dough was prepared, formed into a ball and weighed to 0.70 oz. The dough balls were stored in the refrigerator and were removed on the day of the tasting. All samples were baked at 350˚F but had different bake times. The control required 12 minutes while the 50/50 samples required 13 minutes. The extreme samples baked the longest for 15 minutes. Once removed from the oven, the samples were cooled, and cut into fourths. Twenty-five samples of each type of cookie was assigned to a designated, but random number and placed on a plate for tasting.

Approximately twenty-five tasters filled out scorecards that we provided (Appendix A). They ranked flavor, appearance, texture, tenderness and overall acceptability according to a hedonic scale numbered 1-7. The tasters had no knowledge of any substitutions made to each cookie and were not told that changes had been made to a recipe. The scorecards were collected and used to evaluate likeability of our experimental product.

Results:

Samples	Appearance	Texture	Tenderness	Flavor	Overall Acceptability
#927	5.8	5.6	5.3	5.5	5.3
#659	5.8	5.9	6.1	5.7	5.8
#353	6.0	5.6	5.5	5.5	5.4

Table 1: Average Ratings for Sample Characteristics. The average values varied no more than 0.6 points. Samples 353 and 927 received the same score most often. Sample 659 (control) was preferred in every category other than appearance.

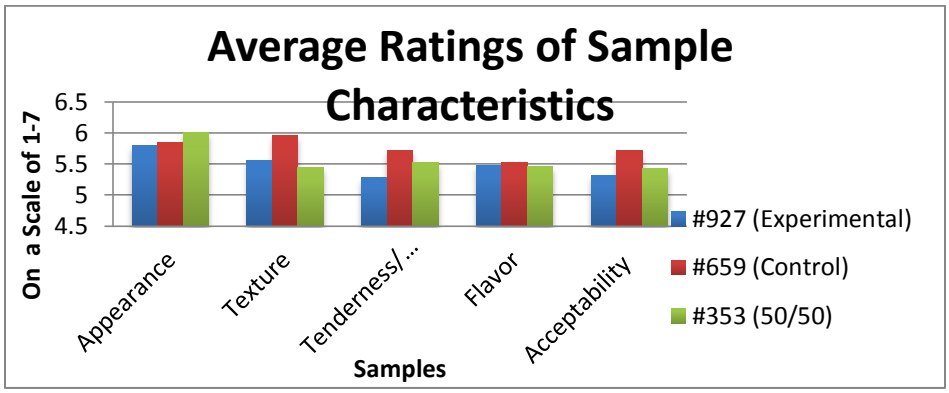

Figure 1. The 50/50 sample had the highest overall rating for appearance. The Control sample had the highest rating for all other characteristics. The experimental sample had lower average ratings compared to the control and 50/50. The average ratings for all samples range from 5.28-6 on a scale of 1-7.

Discussion:

The goal of replacing a substance in food science is for the customer to prefer the altered food or be unable to tell the difference. We measured acceptability preference by conducting a public taste trial in which twenty five people ranked the appearance, texture, flavor, tenderness and overall acceptability of each cookie according to personal preference. A number scale of 1-7 was provided with 1 representing extreme dislike and 7 representing extreme likability. The score of each characteristic was tallied and the average score for each characteristic is described in both Table 1 and Figure 1.

Each characteristic category for all three samples attained average scores that were differentiated by less than one point. While the differences in average ratings of all categories are minuscule, they are still important in deciding which sample cookie was preferred the best in each category. It is clear that the structural and flavor properties of both VCO and butter affects all characteristics that were rated in the public tasting. The control recipe was preferred on average in all categories except for appearance. The tasters preferred the 50/50 recipe's appearance the most on

average, but rated its flavor and texture as being equal to the experimental recipe's flavor and texture. The control recipe ranked highest in overall acceptability while the experimental recipe was ranked lowest.

These scores reflect the different properties oil and butter give to baked goods which arise from their difference in composition. Oils consist solely of fats, whereas butter contains approximately 16% of water (McWilliams, 2012). These differences in composition affect color, texture and flavor of a final product.

For example, the cookie batter made with VCO was a darker brown color, and produced a noticeably darker and grey colored cookie. The cookie batter made with the butter had a light brown color, and the baked cookie produced a golden brown color. The 50/50 batter was a medium brown color, and produced slightly browner cookies than the control. These color differences can be attributed to type of fat used.

Butter contains 80% fat, and 20% milk solids and water, and imparts a mild yellow color to batter. It also provides a golden brown color to baked goods (McWilliams, 2012, p. 269). When we combined the coconut oil with sugar to prepare the cookie dough, the mixture remained dark brown and glossy suggesting that the oil coated the sugar, but that the sugar granules were not being incorporated fully into the oils. This was different than the butter and sugar mixture which became pale, creamy and uniform in texture. Butter, though fairly solid, exhibits plasticity which is the ability to be spread or be creamed. Fats with plasticity are large fat crystals dispersed in oil and can be whipped into a foamy or creamy texture (McWilliams, 2012, p. 268). While coconut oil is harder than butter when refrigerated, it is softer at room temperature and did not exhibit the same plasticity when being creamed with sugar nor did it spread as far as butter in the line-spread test (See Figure 2 in Appendix A).

The line-spread test was conducted in order to measure the spreadability (or plasticity)of coconut oil and butter and observe how each affects baked cookie size (see Figure 2 in Appendix

A). Spreadability of a fat is affected by how saturated it is. If a fat is more saturated, it spreads less. Coconut oil is 92% saturated (Chomchalow, 2011) while butter is only 50.5% saturated (McWilliams, 2012, p. 263) and this explains why dough made with butter spread farther than the dough made with coconut oil (See Figure 2 in Appendix A).

Interestingly, the experimental recipe and the 50/50 recipe received equal likeability scores in the tenderness/moisture category while the control recipe received the highest score. This suggests that butter, used alone, is superior in creating tender cookies and that mixing oil and butter results in a less tender product. Tenderness is dependent on the fat content's ability to interfere with the development of gluten, a protein found in flour. A softer fat or oil can spread over a larger surface area in the flour mixture, increasing tenderness (McWilliams, 2012, p. 271). This is referred to as shortening power. Coconut oil is softer at room temperature and has a lower melting point than butter, so it was surprising that the cookies containing it were rated less tender. Perhaps this is because it exhibits less plasticity and does not spread as much, possibly lessening its shortening power. It is also possible that the tenderness scores for the experimental cookie were lower due to coconut oil's lack of water content.

Moisture is a way to describe food's water content and contributes greatly to texture. To determine moisture in our samples, we conducted a wettability test. The control cookie absorbed .35 oz of water, whereas the experimental cookie absorbed only .20 oz of water. The 50/50 cookie absorbed 0.30 oz of water, which is less than the control, but more than the experimental (See Figure 3 in Appendix A).

If a sample contains more water before the test, it will absorb more water during the test because water molecules are strongly attracted to one another. The control cookie absorbed the most water and this indicates that using butter results in a more moist cookie than one that uses coconut oil. This result is consistent with what types of fats butter and oil are. Unlike oil, which is pure fat,

butter is a water- in- oil emulsion which means water molecules are trapped between fat molecules allowing products made with butter to remain moist and tender (McWilliams, 2012, p. 270-272).

The flavor of our cookies was also altered by the use of butter and coconut oil and this certainly affected likability scores. Butter is widely used and its flavor may be more familiar and thus more appealing than coconut oil. Coconut oil's rich and distinctive flavor is not well liked by everyone and this factor cannot be ignored when evaluating the results of the public tasting. We used a recipe that called for shredded coconut to mask this obvious flavor difference; however this may have caused the coconut flavor of our experimental cookie to be overpowering.

All of the factors judged are important in determining overall acceptability. It is not surprising that our control recipe was most accepted based on the average scores in the other categories, although it is surprising when looking at the raw scores. The experimental cookie received several comments such as, "LOVE," and "All very tasty but #927 is the best overall," however people's personal preference for coconut seemed to be the determining factor in overall acceptability as untrained tasters tend to like foods that taste the best.

CONCLUSION:

The structure of a fat greatly influences the flavor, appearance and texture of baked products. While the results of our tasting show that people prefer cookies made with butter, the average scores were very close in value. We are satisfied with the results and think that virgin coconut oil is an acceptable substitution for butter, especially for consumers who need to decrease their cholesterol intake.

The benefits of ingesting virgin coconut oil may include decreased LDL cholesterol, increased HDL cholesterol, increased insulin sensitivity and increased immunity to certain viral and bacterial infections. However, a diet relatively low in fat is still most beneficial in preventing heart disease. Rising consumer demand is inspiring new and thorough research of coconut oil's health benefits.

Works Cited

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Appendix A

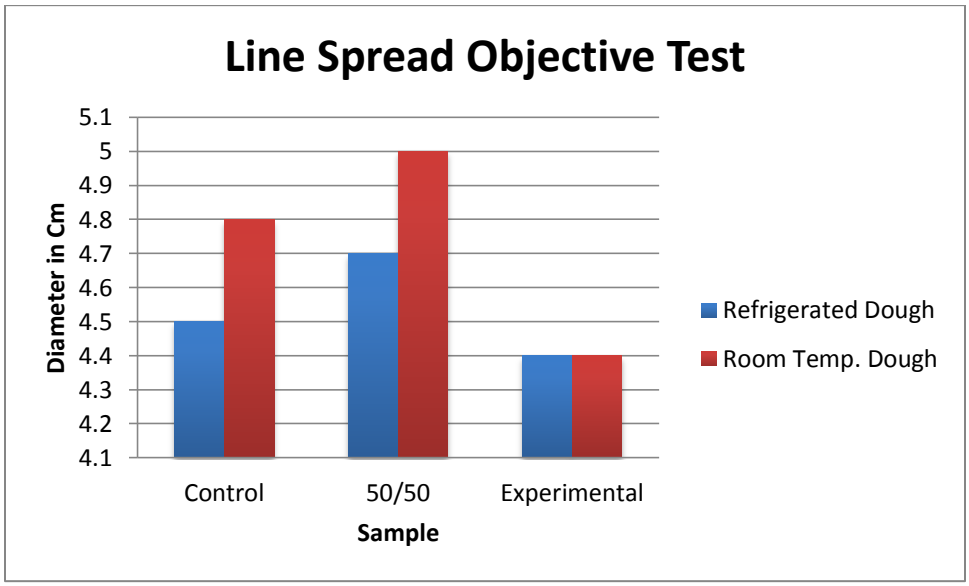

Figure 2. Spreadability was measured in both refrigerated and room temperature dough. The room temperature dough spread farther except for dough made with virgin coconut oil.

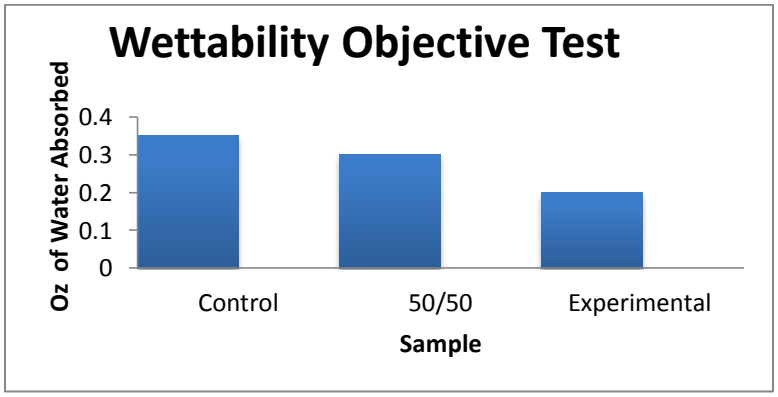

Figure 3. The control sample absorbed 0.35oz of water, the most amount of water absorbed of all samples. These results indicate that our control cookie was the most moist.