Mastering Mascarpone: What it takes to make a perfect batch of Mascarpone Cheese

by

Tessa Buratto

Dairy Science Department

College of Agriculture, Food and Environmental Sciences

California Polytechnic State University

San Luis Obispo

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ABSTRACT

Many people enjoy the delicious Italian cheese known as mascarpone in numerous dishes, such as Tiramisu, pasta, and fresh fruit. Some people even choose to make their own mascarpone at home rather than purchasing a commercial product available. The objective of this experiment was to first determine if it is possible to make mascarpone cheese in a noncommercial setting, and then to formulate ideal parameters to creating a perfect batch of mascarpone cheese. This will allow those at home and in commercial operations to have access to a scientifically tested formula and procedure that can be utilized for an operation of any size. The experiment began by testing three commercial samples of mascarpone for their components using standard tests and equipment such as the Babcock method for fat content. Then a formulation for a standardized mix of whole milk, skim milk, and cream was created to make cheese with, and finally the mascarpone making began. After evaluating the cheeses and the test results, it was time to then determine which type of acid would not only make the highest quality cheese, but also give the greatest yield, and be the most profitable. The choices of acids to be used were vinegar, citric acid, and lactic acid. After successfully making multiple batches of mascarpone from each type of acid it is now known all choices are possible for cheese production. When comparing the results of yields, fat recovery, components, and characteristics, a conclusion can be made. Looking at the highest yield and fat recovery, we see that vinegar has the greatest results with a yield of nearly 40%, and a fat recovery above 90%. Although using vinegar attains the highest yield, the mascarpone made with the citric acid was preferred for its taste, and texture, and being most similar to the commercial products. Also, the citric acid measures closely to the vinegar mascarpone in yield and fat recovery (80%). Therefore, it appears that citric acid is the best choice to use for making the perfect batch of mascarpone.

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INTRODUCTION

Every cheese has a story. There are thousands of different cheeses all over the world, each unique in their own way. Each has a history of origin, make process, specific characteristics, and uses. Some cheeses are well known and commonly recognized like Cheddar and Swiss, while others are less familiar the common consumer like Quark and Mascarpone. New varieties of cheeses are constantly being made and developed by artisan cheesemakers, as they focus on creating new and one unique products that fit into and create niche markets. The beauty of making cheese is being able to take milk, a simple raw material, and create a value added product with special, one-of-a-kind qualities that pleases hundreds, maybe even thousands of consumers.

Mascarpone is one of those cheeses that unless your Italian or a chef, you probably haven't heard of it, used it, or tasted it. Being Italian and having the dream of being a cheesemaker, it seemed logical to agree to take on the project of making the perfect mascarpone. Being able to formulate the highest quality product that can be shared and enjoyed by others, while working on my cheese making and dairy chemistry skills led me to this senior project. My goal was to find the best formulation that creates the most delicious mascarpone cheese that could be adjusted to work for any size production scale. After hours of researching, testing, processing, and tasting, I believe that I have found the secret to a perfect batch of mascarpone cheese, or at least what some well-tested guidelines are. With the hope of expanding the common consumers' knowledge of this delicious "Italian cream cheese," my senior project will be complete and my dream of being a great cheesemaker is now that much closer.

LITERATURE REVIEW

The History of Cheese

People all over the world have enjoyed cheese for thousands and thousands of years. Many different countries claim the story of its discovery based on local legends passed down from generation to generation. Although the stories' details vary, they seem to have these facts in common: a rider sets out on a journey, taking with him some milk in a leathern pouch made from a young cow's stomach. Hours later he discovers that the milk has turned into a sour, curdy substance that is not unpalatable. But as it turns out, these legends began being told long after cheese was first made. Cheese actually dates back to the early domestication of animals, around 9000 B.C., and it has been made wherever animals produce more milk than people use in fluid form. According to archaeologists cheese was well known and used by the Sumerians (4000 B.C.) as documented in their historical tablets, as well as in Egyptian and Chaldean artifacts.

Cheese is also referenced in the Old Testament and in the book of Samuel. Other historical references to cheese are limited until the time of Greek and Roman Empires. The Roman Empire is often given credit for having a large impact on the production and use of cheese from the spread of new ideas and technology throughout conquered lands. An interesting fact about cheese's past is that it was so crucial to the Roman diet that the Emperor Diocletian set a minimum price for cheese, in an attempt to lessen supply and price problems (Haskell, 1964). Christianity also played a role in the widespread popularity of cheese, due to new life practices and foods during the time of the Crusades, and then also being involved in the pilgrimages to the Holy Land. Most importantly was the influence on the art of cheese making developed from production technologies and cheese varieties made in the monasteries and states of Europe. The

monasteries played a crucial role in the advancement of agriculture products in Europe, and the development of cheese.

During feuding times of the Middle Ages, states became closed communities, and community members had to rely on their own food production. This positively contributed to the advancement of the art and techniques of cheese making, as people's agriculture and farming skills progressed. Thus, specific ways of making cheese were learned and taught, and passed down from generation to generations, developing into regional specialties. Being indigenous to particular regions, many of these cheeses are name-protected cheeses in reference to their country of origin, and can only carry the name if they have been produced there (Smith, 2005).

Cheese making finally reached North America via colonization in the 1600s. As stated by Smith in his book, "The regional differences reflected by the landscapes, animals, and cultures of the immigrants scattered across the continent influenced the kinds of cheeses made in early America". Throughout the U.S. and Canada immigrants made their beloved cheeses from their homeland, and brought recognition to their new homes across North America with their special and new unique cheeses. Until the Industrial Revolution, cheese making had always been a practice on a small scale in local communities. In the pre-industrial age, cheese was a reflection of regional food and flavors that exhibited the uniqueness of the local environment. When factories began producing cheese, the focus moved to profitability and quantity rather than tradition, and resulted in a product that was of bland and boring quality according to most consumers. But as time went on companies perfected their recipes and cheeses to be fine examples of a high quality product produced on a large scale.

Today the story of cheese can be thought of as a rebirth of artisan cheese making. With the available communication, technology, and knowledge, consumers and cheese makers are

looking at ways to go back to their roots and a simpler way of living. Eating for the pleasure of taste and special indulgences, and wanting to support the local community. Organizations such as the American Cheese Society in the US and Specialist Cheese Makers Association in the UK are helping promote the development of small-production farmers and introduce new varieties of cheese to the public and consumers, to continue the growth of the cheese market.

The History of Italian Cheese. Italy is well known for many things, such as its architecture, art, music, and literature, and of course its cheese. Italian cheese is a product of an ancient culture, dating back to the time of the Romans. Italians make cheese from cow, buffalo, sheep, and goat milk, produced in a variety of ways. Italy can claim to the past or present production of 50 different cheese varieties, many of which have influenced how and what people all over the world eat.

The ancient history of cheese production in Italy was considered a regional, or family industry. Cheese was an individual craftsmanship that brought pride to the cheese makers family and local community. Based on point of origin, specific regions of Italy claimed cheeses and their fame, and often named them based on the communities' local surroundings. For example, Parmigiano Reggiano and Grana Padano, which would be called Parmesan, were both made in the valley of the Po (Reinbold). The conditions of the local environment also played a role in the type of cheese that was produced. For instance the valley of the Po had limited keeping ability for fresh foods, so only low moisture, aged cheeses were produced. Gorgonzola is a small Italian village at the foot of the Alps in northern Italy, where a surplus of milk led to the production of Gorgonzola cheese. Comparing the top and the bottom of the country, Provolone, Mozzarella

both originated in southern Italy, while most of the surface-ripened and soft cheese originated in the north of Italy.

Mascarpone: An Italian Specialty

Origin. Lombardy is a region in the northern part of Italy that has a rich agricultural and dairy heritage. Around the late 1500s or late 1600s dairymen of Lombardy became famous for their fresh cheese curds known as Mascarpone (Jones). Correctly pronounced *mas-car-POH-neh*, there are many different thoughts to how mascarpone got its name. It is believed that the name "mascarpone" may come from the Spanish "mas que bueno" ("better than good"), from the days when the Spanish ruled Italy. Another possibility is that the name is derived from "mascarpia," the local dialect term for ricotta, because very similar processes make both ricotta and mascarpone. And lastly, a third possibility is that the name comes from the word "mascarpa," a milk product made from the whey of aged cheese (Zonis, 2005).

Description. Mascarpone is described as a butter-colored soft and delicate cheese made from fresh cream, so smooth and creamy people often relate it to whipped cream. Being milky-white in color and easy to spread, it is commonly recognized as "Italian Cream Cheese." Traditionally mascarpone is made from cow's milk cream, and has a butterfat content of around 75%. According to Cantare Foods's website, a well known commercial maker of mascarpone, the cheese's texture ranges from a light clotted cream to something like butter at room temperature. Mascarpone has a mild taste, making it an ideal base for many different dishes and can incorporate a variety of flavors and ingredients.

Uses. Mascarpone is used in a various dishes of the Lombardy region of Italy, where it is a specialty (Wikipedia). In the region of Friuli a favorite way to use mascarpone is blending it with anchovies, mustard, and spices. More commonly mascarpone is known for being a main ingredient in the delicious Italian dessert Tiramisu. Its mild flavor and soft texture allows it to be used in savory and sweet dishes, making the possibilities nearly endless in the kitchen. The BelGioioso Cheese Company, the market leader for US mascarpone, uses the marketing slogan "half the calories of butter" to lure the interest of consumers to mascarpone. Being that this cheese has such a high butterfat because it is composed of cream, it is similar to butter and can be used in the similar ways. The Cantare Foods website list a variety of uses for mascarpone and what types of foods mascarpone can be used with, which can help the unfamiliar consumer expand their knowledge.

Making Your Own. Mascarpone is made of two simple ingredients: cream and acid. Being a simple fresh cheese to produce, many people attempt to make their own mascarpone right at home in their kitchen. However, if one is to look for a recipe or instructions on how to make this cheese an overwhelming variety of sources are available. Just by Googling "how to make mascarpone cheese," 386,000 results are available in literally seconds. Whether choosing a recipe from a printed or online source, there is a common problem between the different sources of variability, which inflicts the cheese maker with some questions. When comparing these recipes it appears there is no specific or agreed upon type of cream that should be used, as well as the best type of acid for making mascarpone. Overall the process and basic procedures share similar principals, it's just a matter of figuring out what specific ingredients work best for the cheese maker.

Mascarpone is a soft cream-style cheese produced by heat-acid coagulation of cream. The procedure for making mascarpone involves cream being heated, the addition of acid (such as acetic, citric, tartaric, lactic acids, or lemon juice), and the newly formed curd being separated from the whey. Within these general guidelines there is much room for improvement, success, and failure. However, the manufacturing of mascarpone is not unrealistic by any means. We know it was possible make thousands of years ago with limited technology and resources, making present production realistic. Many people have been successful in making homemade mascarpone, as well as in commercial plants.

Commercial Products. Mascarpone is not a common cheese used by the majority of the population like Cheddar and Mozzarella, but luckily for those who know how delicious and useful it is commercial mascarpone is available. Most retailers will generally carry only one brand of mascarpone in their store because it is a low demand product. The most common brand of mascarpone in the US is BelGioiso, as it is the market leader (Gregori, 2010), but is certainly not the only available option. Some other commercial brands include IlVillaggio, Cinque Stelle, Vermont Butter & Cheese Company, Mauri, and Bella Gento.

Recipes. There are many uses for mascarpone when baking and cooking. People enjoy mascarpone plain, sweet, or savory. If you seem to be at a loss of what to do with mascarpone besides making Tiramisu, a creamy pasta dish, or eating it with fresh berries, a quick Google search for “mascarpone cheese recipes” gives you over 400,000 recipes to choose form. For example the website known as RecipeLand.com alone has 50 recipes using mascarpone, ranging from raviolis to cheesecakes.

Basics of Cheese and Cheese Making

Cheese has been a staple in the diet of mankind since animals were first domesticated. Being thought of as one of the earliest "convenience foods" turning milk, a highly perishable liquid, into a product suitable for consumption, transportation, and storage. And as it ages, cheese gains a more developed flavor, either appealing or unappealing. As Jones implies in his book, "cheese is really little more than a form of artificially coagulated milk, yet a craftsmanship that has developed over the ages has modified rustic recipes into recognized products." There are over thousands of different types and varieties of cheese in the world, and many new kinds are still being developed today, keeping the consumers curious and satisfied.

Thankfully, to create some order and grouping between all the thousands of cheeses, there are four basic categories cheeses are classified in: soft, semisoft, firm, and hard. The soft category includes fresh or un-ripened types like Cottage Cheese, Ricotta, Paneer, and Mascarpone. Ripened fresh cheeses are types like Brie and Camembert. Semisoft cheeses are ripened with bacteria and yeast like Brick, Munster, and Limburger. Blue-veined cheeses are also considered semisoft, like Rogquefort and Gorgonzola. Firm cheeses include Cheddars, Emmenthal, and Jarlsburg to name a few. And finally, hard cheeses are those that develop a smooth, grainy texture that are usually grated, such as Asiago, Parmesan, and Romano (Jones, 1976).

Composition of Milk. Because milk is the base of cheese, it is important to have an understanding of what milk is. The composition, and even type of milk plays a large role in the production, effects, and quality of cheese. Milk is often called nature's most perfect food, because it supplies almost all of the nutrients and vitamins that the human body needs. Milk is

composed of water, protein, fat, lactose, vitamins, minerals, and ash. Water takes up the largest portion of milk, being about 87%, leaving 13% as milk solids. When making cheese the most important components of milk are fat, protein, and lactose.

When it comes to making cheese, fat is of great importance, being essential to the cheese making process. It plays a crucial role in cheese production. Fat is a huge part of the forming of the texture and body of a cheese, as well as its flavor and aroma.

Protein in milk can be divided into two categories: casein and whey. Casein is the major protein found in milk. It is important to a cheese maker because it does not dissolve or become expelled in the whey, and ultimately leads to the creation of cheese. Casein, because of its unique structure, has elastic qualities that can shrink or expand, which gives cheese its stretchy texture. Casein and fat combined are the basic structure of cheese, making them the two most important components of milk for a cheesemaker. Whey protein comprises only .06% of milk, and is water-soluble, often lost in the cheese's whey. The structure of whey protein allows it to retain more moisture than casein protein and is non-elastic, so it acts more like a secondary source of solids for cheese making.

Lactose is the natural sugar, or carbohydrate in milk. This is an important element in milk's composition because it serves as the food for the beneficial bacteria (starter culture) required in the cheese making process. Bacteria feed off the natural energy source growing and thriving, starting the process of fermentation. Without lactose there would be no cheese.

Specifics on Mascarpone's Ingredients

Cream. Cream is the name given to the natural layer of butterfat that forms on top of milk when it sits untouched for a length of time. As the fat globules separate from milk they rises to the top, binding together. As the fat level in cream rises, the levels of the other components (water, fat, lactose, protein, and ash) decrease. It is also understood that when the fat percentage increases the cream usually becomes more viscous. When looking at making mascarpone, the level of fat in the cream used is unclear as it differs between recipes. According to Mr. Gregori of Cantare Foods, there is no federal standard for the manufacturing of mascarpone, which leaves a lot of room for variables.

Types of Acid. In order to make mascarpone cheese, the addition of acid is required. One goal of this experiment was to determine which type of acid, either vinegar (acetic acid), citric acid, or lactic acid, creates the best mascarpone.

- Vinegar is a combination of acetic acid and water and is made by the fermentation of ethanol. The acetic acid concentration is normally 5% by volume for table vinegar but is much higher for pickling. There are many types or flavors of vinegar such as apple cider, balsamic, fruit, malt, rice, white, wine. Vinegar is easily accessible, commonly found wherever food is sold (Cheese Forum, 2010).

- Citric Acid is a weak organic acid found in a variety of fruits and vegetables, most notably citrus fruits, with lemons and limes having the highest concentration. Citric acid is commonly used as a natural food preservative, to add an acidic, or sour taste to foods and soft drinks. Citric acid can be found in large grocery stores, or in supply stores for cheesemaking, wine, beer, etc (Cheese Forum, 2010).

- Lactic acid is formed by natural fermentation in products such as cheese, yogurt, soy sauce, sourdough, etc. Lactic acid is also used in a wide range of foods such as bakery products, meat products, dairy products, etc. Lactic acid in food products usually serves as either as a pH regulator, preservative, and flavoring agent (PURAC, 2010).

MATERIALS AND METHODS: Part 1

Commercial Product Samples:

In order to determine what the perfect mascarpone cheese consists of, three commercial mascarpone samples already on the market were purchased to evaluate and test. Their given product information which was attained from their labels is listed below in Table 1. The next step in his experiment was to begin testing the samples for moisture, solids, protein, fat, and pH.

TABLE 1. Mascarpone Sample Information (attained from product label)

SAMPLE:	**BelGioioso**	**Cantare**	**IlVillaggio**
COST:	$4.49	$3.69	$7.99
PRODUCED IN:	WI, USA	CA, USA	Italy
INGREDIENTS:	Past. Milk & Cream, Citric Acid	Past. Cream, Milk Solids, Citric Acids	Past. Cream, Citric Acid
CALORIES:	60/ tbsp	60/tbsp	100/tbsp
FAT CALORIES:	60	55	90
TOTAL FAT:	6g	6.5g	10g
SATURATED FAT:	3.5g	4g	7g
PROTEIN:	<1g	.5g	1.6g
	B.F 48%, Moist. 43%		

FIGURE 1. Commercial Mascarpone Samples purchased in San Luis Obispo, CA

Moisture and Solids

Testing for moisture and solids was done in the CEM LabWave 9000 Moisture/Solids Analyzer. As explained in the owner's manual, The CEM LabWave 9000 Moisture/Solids Analyzer is an analytical instrument designed to provide rapid moisture/solids analysis. It consists of three major components: a microwave drying system, an integrated analytical balance, and digital computer. Using microwave energy, the moisture and solids content of the sample is automatically calculated based on the new weight after drying (Labwave 9000, p1).

Materials: Mascarpone samples, CEM sample pads, LabWave 9000, spreading knife

Procedure:

1. Turned on LabWave
2. Used F2 button to put on "cheddar cheese" setting, hit enter
3. Placed 2 CEM sample pads under box and hit tare
4. Spread sample on bottom paper thinly like butter until it weighs enough (2-3g)

5. Placed top paper on sample

6. Put in microwave under box, hit start

7. Recorded data, did for each sample twice

FIGURE 2. Spreading Mascarpone samples onto CEM sample pads

FIGURE 3. Sample placed onto scale device in LabWave to be tested

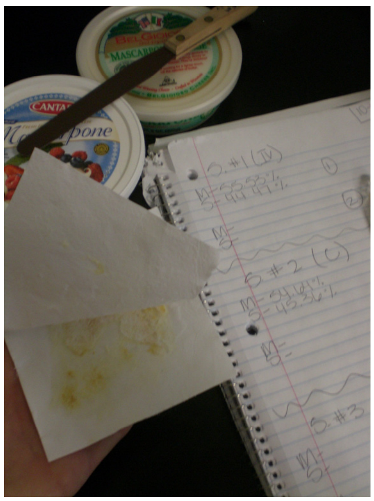

FIGURE 4. Looking at results= dried sample

Protein Testing

Testing for protein was done using the Elementar Rapid N Cube. This machine uses gaseous chromatography to analyze the protein content of a sample.

Materials: Mascarpone samples, tin foil squares, Aspartic Acid (used as standard), digital scale (Metler Toledo), pill shaping form, Rapid N Cube, computer to read data

Procedure:

1. Took a foil square and formed it into a bowl using the pill shaping form
2. Tore the weight of the foil
3. Put .1g of sample into the foil bowl
4. Balled up the foil, droped into pill shaper and pressed into compact pill
5. Re-weighed the formed pill
6. Droped the pill into the designated slot on the top of the cube

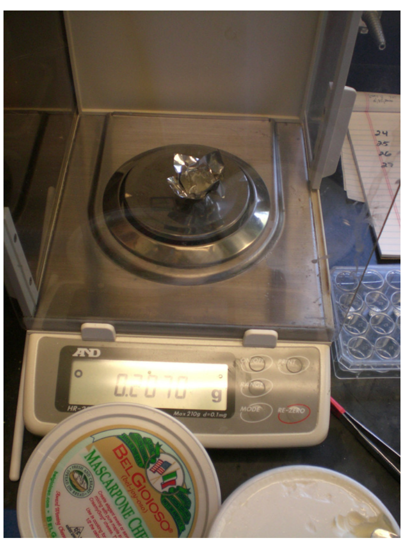

FIGURE 5. Weighing formed foil bowl

FIGURE 6. Weighing .1g of sample to be placed into bowl

Fat Testing

The AOAC official Babcock Test Method was used to test the fat of the mascarpone cheese samples.

Materials: Mascarpone samples, 6 Babcock bottles, 6 rubber stopper, deionized water, hot water bath, sulfuric acid, mechanical shaker, centrifuge, compass measuring device, digital scale, rubber gloves, goggles

Procedure:

1. Tore the weight of a Babcock bottle, weighed 9 grams of sample into the bottle. Made sure the water bath is heating.
2. Pipetted 10mL of hot water (roughly 60 degrees C) in to the neck of the bottle and put the bottle in to the mechanical shaker for 5 minutes to suspend the cheese.
3. Wearing gloves, held the bottle at a slight angle and added a total volume of 18mL of sulfuric acid in 3 aliquots. Swirled the bottle after each acid addition. The time for the complete addition of acid should not exceed 20 seconds.
4. Shook for 5 minutes in the mechanical shaker.
5. Placed bottles in to centrifuge, making sure its balanced, and ran for 5 minutes.
6. Stopped centrifuge and added hot water to the base of the neck on the bottle
7. Returned to centrifuge, balanced, and ran for 2 minutes
8. Stopped the centrifuge and added hot water to the second to last marker of the bottle
9. Returned to centrifuge, balanced, ran for 1 minute
10. Stopped the centrifuge, transfer the bottle to the water bath, made sure the water level is above the upper level of the fat column in the neck of the bottle.

11. Tempered the samples in the water bath for at least 5 minutes

12. Measured the fat column using the compass. Placed the divider points on the vertical line on the neck of the bottle with one point at the bottom of the lower meniscus and the other point at the top of the meniscus. Without changing the distance between the two points on the dividers, moved the dividers down the bottle neck until the lower point rests in the 0% mark. Placed the upper point against the bottle graduation and read the fat content. This is the percent fat in the sample.

FIGURE 7. Ready bottles of samples

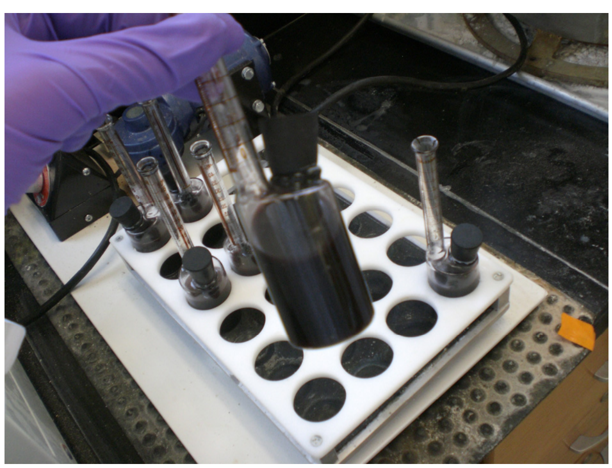

FIGURE 8. Samples after acid added

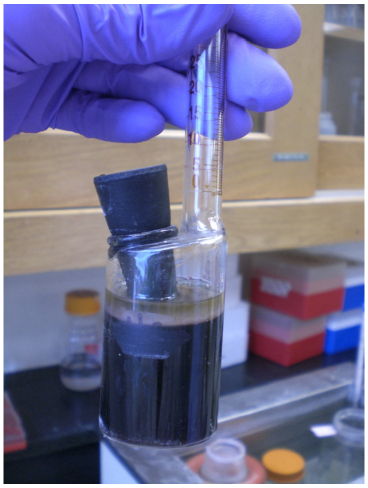

FIGURE 9. Fat line forming

FIGURE 10. Formed fat columns

pH Testing

Testing the pH of the samples was done by the simple method using a digital pH meter. In order to make the cheese into a liquid sample the slurry method was used prior to the pH meter.

Materials: Mascarpone samples, Teckmar Stomacher, pH meter (Orion pH 410), 3 plastic bags, deionized water, scale, small measuring beaker, 2 buffers for calibration

Procedure:

1. Tore bag, added sample to bag
2. Added equal parts water to bag and closed
3. Put bag in Stomacher to mix the water and cheese   into a slurry
4. Checked pH meter with buffers to make sure its calibrated
5. Lightly rinsed pH meter with deionezed water and dabbed dry with paper towel
6. Tested slurry mixture with pH meter, read results

Cream, Whole Milk, and Skim Milk Testing

Before making a batch of mascarpone, the cream, whole milk, and skim milk needed to be tested in order to know the levels components. After testing for total solids, protein, and fat, it will be possible to standardize the cream. The goal was to make two standardized mixes, one of cream and whole milk, and the other of cream and skim milk that both have 20% fat. This was done using the Pearson Square Calculation Method. After standardizing the two mixtures, they were tested for pH, total solids, protein, and fat.

Total Solids Testing

Total solids' testing was done the same way as the mascarpone was tested, as explained prior.

Fat Testing

The Babcock method was again used to test the samples for fat. The procedure for testing cream and milk was almost exactly the same except for different amounts of sample being used and the addition of water to the cream sample prior to the sulfuric acid being added.

Materials: Cream, whole milk, skim milk, 2 Babcock cream bottles, 2 Babcock milk bottles, 2 Babcock skim milk bottles, deionized water, hot water bath, sulfuric acid, mechanical shaker, centrifuge, compass measuring device, digital scale, rubber gloves, goggles

Procedure:

1. Weighed out 9 grams of cream and 18 ml of whole milk and skim milk, put in the correct bottle types.

   * Added 9mL of deionized water to the cream @ 60 degrees C

2. Wearing gloves, held the bottle at a slight angle and add a total volume of 18mL of sulfuric acid in 3 aliquots. Swirled the bottle after each acid addition. The time for the complete addition of acid should not exceed 20 seconds.
3. Shook for 5 minutes in the mechanical shaker.
4. Placed bottles in to centrifuge, making sure its balanced, and ran for 5 minutes.
5. Stopped centrifuge and added hot water to the base of the neck on the bottle
6. Returned to centrifuge, balanced, and ran for 2 minutes
7. Stopped the centrifuge and added hot water to the second to last marker of the bottle
8. Returned to centrifuge, balanced, ran for 1 minute
9. Stopped the centrifuge, transferred the bottle to the water bath, made sure the water level was above the upper level of the fat column in the neck of the bottle.

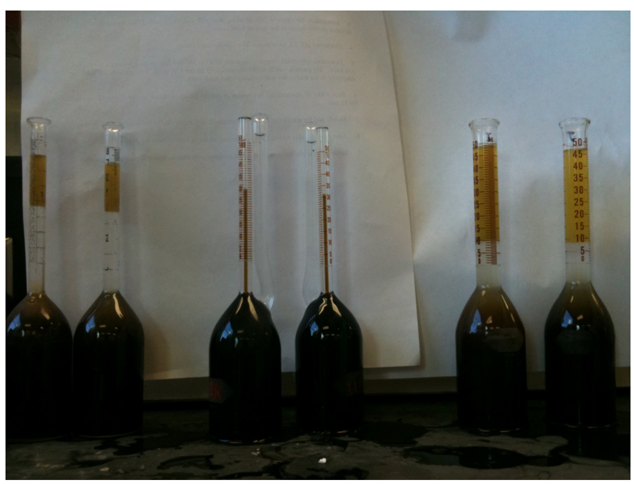

FIGURE 11. Fat columns formed

Standardizing

Now knowing the content of fat already present in the milks and cream, it was possible to create a standardized mix to achieve the specific fat content desired. Standardization is the process of adjusting the composition if milk for specific processing and manufacturing needs. One of the simplest methods of adjusting the fat content of dairy products is to use the Pearson Square or Rectangle. This method can only be used when blending two components, giving you the end result of the correct proportions of milk and skim that must be mixed together to attain the desired fat content. Using the Pearson Square Method a mixture of milk and cream was created to achieve the desired fat content of 20%. Two different mixes were made; one with cream and whole milk, and the other being cream and skim milk (Mullan, 2006).

Procedure:

1. Drew a rectangle. In the center wrote the desired fat content, in the upper left corner wrote the fat concentration of the cream, in the bottom left corner wrote the fat concentration of the skim
2. Worked diagonally making an equation of (cream minus fat) and (fat minus skim) getting the unknowns on the right side
3. Added the right side gives the total volume of the mix

TABLE 2. Pearson Square for Skim Milk

Cream: 39.7 (=.50)		19.99
	20% Fat	
Skim: 0.01% (=.50)		19.7

=39.69

TABLE 3. Pearson Square for Whole Milk

Cream: 39.7 (=.46)		16.725
	20% Fat	
WM: 3.275% (=.54)		19.7

=36.425

Testing Milks and Cream Protein Levels

Protein levels of the whole milk, skim milk, and cream were again tested using The Elementar Rapid N Cube. The only change in materials and procedure is instead of creating a pill of a solid cheese sample a capsule is created to hold the liquid inside.

Materials: milk and cream samples, tin capsules (.5mL), Aspartic Acid (used as standard), digital scale (Metler Toledo), capsule pincher device, oxygen tank/ hook up, Rapid N Cube, computer to read data

Procedure:

1. Tore empty tin capsule on scale
2. Shook sample up sample. Weighed 300-400mg of sample into capsule
3. Opened oxygen valve on capsule pincher
4. Placed capsule into pincher and pinch completely
5. Weighed capsule, hit print
6. Placed capsule into designated spot in cube

Mixing Standardized Milks

From the Pearson Square Method used above, creating the two types of cream mixes were created to equal 20% fat. The determined ratios per 1 liter are as listed below in TABLE 4.

Procedure:

1. Divided each newly found standardized number on the right side by the total volume to find the amount of each component needed

   SKIM MIX: 19.99/ 39.69= .50 cream, 19.7/ 39.69= .50 skim

   WM MIX: 16.725/ 36.425= .46 cream, 19.7/ 36.425= .54 wm

2. Multiplyed the answers by 1000 to get the mL needed to create 1 liter total mix

Cream and Skim Milk Mixture	Cream and Whole Milk Mixture
Cream: 500mL Skim Milk: 500mL	Cream: 460mL Whole Milk: 540mL

TABLE 4. Mix mLs needed

Testing the Standardized Milk Mixes

Testing for the mix's solids was done with the same procedure as the cheese maples, except the setting on the LabWave was set to "Milk" instead of "Cheddar Cheese". And, the sample was pipetted on to the sample pad because it was liquid.

Testing the Standardized Milk Mixes' pH

pH testing was done the same way as prior with the cheese samples.

Making Mascarpone

After researching mascarpone and the many recipes available on how to make it, I decided to follow the general procedure of cooking the cream, adding an acid, and draining the curds from the whey. For the first batch of trial mascarpone vinegar was used as the acid of choice.

Materials: Standardized Milk Mixes, Acids (Vingear (4% acetic acid), Citric Acid, Lactic Acid), 2 1000mL glass beakers, 2 stir sticks, 4 cheese clothes, 2 strainers, 2 buckets, 2 rubber bands, thermometer, hot plate, wide/round spreading knife

Procedure:

1. Measured out cream, whole milk, and skim milk in quantities determined before (See TABLE 4.)
2. Poured the measured mixes into a separate beaker (one for the WM mix, one for Skim mix)
3. Heated the cream and milk mixes to 85-86 degrees C on hot plate, and held at that temperature for 30 minutes, stirred constantly
4. Slowly added 25mL of vinegar to the hot mix, stirred it thoroughly until done
5. After the acid is added and mixed, let the hot mix sit for at least 10-15 minutes to allow the curd to form
6. Placed cheese cloth in strainer set over the bucket (one for each mix)
7. Checked the curd with the knife, once well formed slowly poured the hot mix into the set-up strainer and let the whey start to drain form the curd

8. When cool enough, gathered the cheesecloth and formed the bundle of curd into a gathered ball, twisted the cloth to tighten the curd ball and use a rubber band to hold
9. Placed the fresh cheese into a refrigerator and allow it to drain for 24 hours

FIGURE 12. Formed curd from the addition of vinegar

FIGURE 13. Ready to drain whey

FIGURE 14. Fresh, formed mascarpone cheese ready to cool

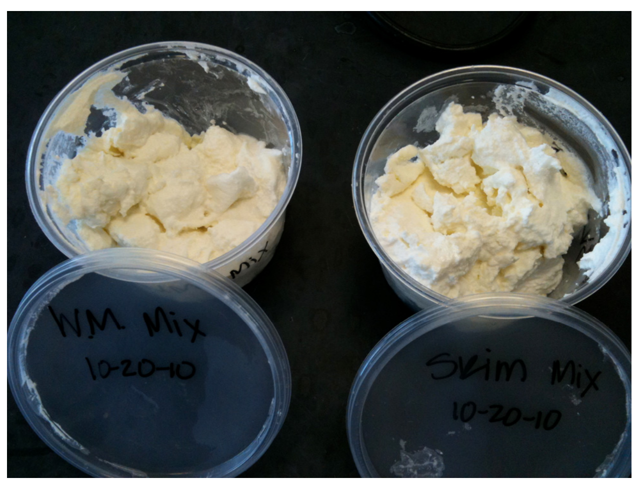

FIGURE 15. Fresh mascarpone cheese! The WM batch & Skim batch 24 hours later

Knowing that making mascarpone in the lab is indeed possible my first goal was achieved! After sampling, testing, and comparing the two versions of mascarpone, it was decided that further mascarpone cheesemaking and testing would be done with the whole milk and cream mix only.

MATERIALS AND METHODS: Part 2

The second goal of this experiment was to determine the best type of acid to be used when making mascarpone. As discovered from evaluating the commercial samples, and researching published recipes for mascarpone, using citric acid is commonly the acid of choice. Vinegar (acetic acid) was the chosen to be used on the first trial of making mascarpone because it is highly acidic and easily accessible to the common consumer. Now knowing that vinegar can in fact be used to make mascarpone, testing other acid options to find the best choice for cheesemaking was the next. Citric acid and lactic acid were chosen to be the other types of acids to be used, because they are already proven safe and used in dairy processing.

Titratable Acidity Testing

Knowing that the vinegar used was 4% acidity, it was necessary to test the citric and lactic acid to determine what quantity is needed to equal the same strength.

Materials: Phenolphthalein solution (1%), citric acid, TA crushiable, acidity test stirring rod, TA apparatus, NaOH (.1%), lactic acid, deionized water, scale, volumetric flask

Vinegar & Citric Acid Procedure:

1. Measured 2g of acid into volumetric flask

2. Filled the base of flask with deionized water and mixed the citric acid until dissolved. Then finished filling the flask until the mix reached the white line (50mL)
3. Pipetted 9mL of citric acid mix into TA crushable
4. Added 4 drops phenolphthalein
5. Filled burette on apparatus by pumping air bulb (thumb over hole on tube)
6. Slowly started to add NaOH while stirring acid mix
7. Stopped when reached a light pink color. Determined how many mLs it took to reach pink

Vinegar- 4% acidity, took 61.52mL= 6.152 TA

Citric Acid- 4% acidity, took 56.5mL= 5.65 TA (less acidic than vinegar)

Lactic Acid Procedure

Knowing that the lactic acid used was 88% pure, using the equation C1 xV1=C2 x V2 it is possible to determine how much lactic acid is needed to make an equal volume to volume solution. Plugging in the numbers to find V1, (V1=4.0 x 50.0/ 88.0) we find that V1= 2.27 mL of lactic acid is needed. Then find the around of water to dilute the solution (50mL-2.27mL= 47.73mL)

Followed the same procedure steps above to find TA

Lactic Acid- 4% acidity, took 41.1mL= 4.11 TA (least acidic, weakest acid)

Calculation of acid needed

Next, to equally match the strength of the 25mL of vinegar used in the previous batches of mascarpone, the amount of lactic and citric acid needed to be found. Dividing the TA of the vinegar into the other acid's TA and multiplying by 25mL will give the amount of acid needed.

Citric: 6.152/ 5.65 x 25.0= 27.2mL needed

Lactic: 6.152/ 4.11 x 25.0= 37.4mL needed

Because the lactic acid is the weakest and required a much higher volume for cheesemaking, it was decided that strengthening the concentration to lessen to volume to be closer to the vinegar's and citric's would be a better choice.

Lactic Acid- 5% acidity, took 51.2mL= 5.12 TA

Lactic: 6.152/ 5.12 x 25.0= 30mL needed

Cheesemaking With All 3 Acids

The same cheesemaking procedure used to make mascarpone with vinegar was followed to make mascarpone with the citric and lactic acid. The only variation was the volume of each specific acid used.

After the cheese was made, tests for the %fat in the whey and cheese were done (using the Babcock method again). The yield of each acid type cheese where also calculated to determine what acid works most efficiently and will be the best choice economically for a mascarpone producer.

RESULTS AND DISCUSSION

Commercial Mascarpone Samples

After running test for solids, moisture, fat, protein, and pH, the answer of what exactly a commercial mascarpone is composed of was attained. Below in TABLE 5. are the results of the tests on all three purchased mascarpone samples. From these results, we now have guidelines to what the accepted and normal product type is like.

Sample:	**BelGioioso**	**Cantare**	**IlVillaggio**
Moisture (1)	43.60%	54.64%	55.53%
Moisture (2)	44.06%	54.48%	56.50%
Av. Moisture	**43.83%**	**54.56%**	**56.02%**
Solids (1)	56.40%	45.36%	44.47%
Solids (2)	55.94%	45.52%	43.50%
Av. Solids	**56.17%**	**45.44%**	**43.99%**

TABLE 5. Results of testing on commercial mascarpone samples

Protein (1)	4.685%	6.843%	5.670%
Protein (2)	4.585%	6.964%	5.575%
Av. Protein	**4.64%**	**6.90%**	**5.62%**
Fat (1)	49.5%	33.0%	35.0%
Fat (2)	50.0%	33.5%	35.0%
Av. Fat	**49.8%**	**33.3%**	**35.0%**
pH	**6.58**	**6.41**	**6.13**

Skim and Whole Milk Mascarpone

The original batches of mascarpone cheese were made with the standardized skim and whole milk mixes. Below, in TABLE 6., 7., 8., and 9., are the result of the milk mixes' solids testing for %fat, protein, moisture, solids, and pH prior to cheesemaking.

TABLE 6. Milk, Cream, and Mix Fat

	Test 1	Test 2	**Average**
Cream	40%	39.4%	**39.7%**
WM	3.3%	3.25%	**3.275%**
Skim	.01%	.01%	**.01%**
WM Mix	19.8%	20.3%	**20.05%**
Skim Mix	20.0%	19.5%	**19.75%**

TABLE 7. Milk, Cream, and Mix Protein

	Test 1	Test 2	**Average**
Cream	2.43%	2.09%	**2.26%**
WM	3.48%	3.47%	**3.48%**
Skim	3.60%	3.51%	**3.56%**
WM Mix	2.84%	2.79%	**2.84%**
Skim Mix	2.88%	2.82%	**2.85%**

TABLE 8. Standardized Milk Mix % Solids

	Test 1	Test 2	**Average**
WM	26.12%	26.19%	**26.16%**
Skim	26.05%	26.19%	**26.12%**

TABLE 9. Standardized Milk Mix pH

	Test 1	Test 2	**Average**
WM	6.92	6.92	**6.92**
Skim	6.99	6.98	**6.99**

Once cheese was made with the milk mixes, it was tested for % fat (TABLE 10.), % solids and moisture (TABLE 11.), and the pH (TABLE 12.). These results are below in the following tables:

TABLE 10. Cheese (Trial) % Fat:

	Test 1	Test 2	**Average**
WM	38%	39%	**38.5%**
Skim	36%	35%	**35.5%**

TABLE 11. Cheese (Trial) % Solids and Moisture:

	Test 1	Test 2	**Average**
WM Solids	50.75%	49.04%	**49.9%**
Skim Solids	46.50%	47.46%	**46.98%**
WM Moisture	49.25%	50.96%	**50.11%**
Skim Moisture	53.50%	52.54%	**53.02%**

TABLE 12. Cheese (Trial) pH:

	Test 1	Test 2	**Average**
WM	6.01	5.99	**6.0**
Skim	6.05	6.08	**6.07**

After comparing the results to the commercial samples and each other, it was decided that to keep the variables limited, the rest of the cheesemaking trials and testing would be done with only the whole milk and cream mix, and to no longer use the skim milk mix.

The next step in reaching the goal of finding what acid works best to make mascarpone was to start making more cheese! Because the acid had already been tested for TA and the calculations were done to determine the quantity needed of each per batch of cheese, it was easy to start. TABLE 13. Shows the results of the needed acid quantities.

TABLE 13. TA and Acid Quantity Needed

Vinegar (4%)	Citric Acid (4%)	Lactic Acid (5%)
6.152 TA	5.65 TA	4.11 TA
25mL needed	**27.2mL needed**	**30.0mL needed**

Making the three different batches of mascarpone was exciting! Getting to see a final product finally that was the result of all the prior reach and testing and calculating was very rewarding. There were definite differences between each batch of cheese due to the effects of the acid used. The final batches of mascarpone were tested for moisture, solids, fat, pH, and the %fat in whey. Prior to making cheese the weights of the milk and equipment were also recorded so final calculations of yield and fat balance could be done once the cheese was made.

TABLE 14. Final Cheese Results:

	WM Vinegar	WM Citric	WM Lactic
Moisture (1)	50.11%	52.43%	49.52%
Moisture (2)	50.49%	52.83%	50.20%
Av. Moisture	**50.30%**	**52.63%**	**49.86%**
Solids (1)	49.90%	47.57%	50.48%
Solids (2)	49.52%	47.17%	49.80%
Av. Solids	**49.71%**	**47.37%**	**50.14%**
Av. Fat	**45.5%**	**40.5%**	**41.5%**
Av. %Fat in Whey	**8.5%**	**11.5%**	**16.5%**
Av. pH	**6.11**	**5.97**	**5.89**

FIGURE 16. Results of testing the whey for %fat

After getting all the results on the three cheeses made, it was interesting to see how the experiment products matched up to the commercial samples. Finding the averages of all three commercial mascarpone components as well as the combined averages of the experiment mascarpone gave a simple snapshot of the similarities and differences. The results are listed in TABLE 15. I am happy to see that my products match very closely to the commercial!

TABLE 15. Product comparison based on averages

	Commercial	**Experiment**
Av. Moisture	51.47%	50.93%
Av. Solids	48.53%	49.07%
Av. Fat	39.37%	42.50%
Av. pH	6.37	5.99

Now knowing that it is indeed possible to create mascarpone cheese with different types of acids, and analytically match the commercial products on the market, evaluating the economic value of the mascarpone results remains. Calculating the yield of each type of mascarpone made based on the beginning and ending weights was the first step to achieving this goal. TABLE 16 shows the weight that were recoded and used to determine the economic portion of the results.

TABLE 16. Recorded Weights:

	WM Vinegar	**WM Citric**	**WM Lactic**
Milk	976.73g	961.62g	975.88g
Whey	446.66g	439.39	651.82
Cheese	387.74g	375.34	215.87

Percent yield of the mascarpone is an important aspect of production. A cheese producer wants to have the greatest yield possible because it means the components in the milk are being utilized the best way possible, and the most product is being made. By calculating the yield of each

mascarpone, we see that vinegar and citric acid give nearly the same yield, quite higher compared to lactic acid. Therefore as a cheese producer it would make sense to use vinegar and citric acid over lactic so that you end with more mascarpone per batch.

TABLE 17. % Yields of each Mascarpone: (cheese wt/ milk wt)

	WM Vinegar	**WM Citric**	**WM Lactic**
Yield	39.69%	39.03%	22.12%

Next, the weights were used to calculate the fat recovery of the cheese, which is the real sign of efficient cheese making. In order to find the fat recovery the fat in milk, fat in cheese, and fat in whey, were first calculated (see TABLE 18.,19., 20.).

TABLE 18. Fat in Milk: (milk wt. x %fat)

Vinegar	976.73g x .20= **195.37g**
Citric	961.62g x .20= **192.32g**
Lactic	975.88g x .20= **195.18g**

TABLE 19. Fat in Cheese: (cheese wt. x %fat)

Vinegar	387.74g x .455= **176.42**
Citric	375.34g x .405= **152.01**
Lactic	215.87g x .415= **89.58**

TABLE 20. Fat in Whey: (whey wt. x %fat)

Vinegar	446.66g x .085= **37.97**
Citric	439.39g x .115= **50.53**
Lactic	651.82g x .165= **107.55**

Now having the needed number to complete the fat recovery calculation, a conclusion of what is acid gives the greatest bang for your buck can be determined. Looking at my calculations vinegar seems to give the greatest recovery, much above lactic acid. Citric acid is a close second in fat recovery, and was nearly the same in yield.

TABLE 21. Fat Recovery: (fat in cheese/ fat in milk x 100)

Vinegar	176.42/ 195.37= **90.30%**
Citric	152.01/ 192.32= **79.20%**
Lactic	89.58/ 195.18= **45.90%**

Knowing all the statistical information from the different batches of mascarpone, there is still another set of results to be considered in evaluating what acid created the perfect batch of mascarpone, meaning the product attributes. Looking at the differences between each type of mascarpone, and evaluating them based on sight, feel, and taste, some common results (see TABLE 22.) were concluded between a sample group of eight people in the dairy processing industry. All the mascarpone was palatable, and tasted quite delicious! There was a definite favorite when comparing the three versions, everyone preferred the taste and consistency of the mascarpone made with citric acid.

TABLE 22. Cheese Characteristics:

Vinegar	Firm/ thick, off white color, cooked cream flavor
Citric	Softest/ easily spreadable, white color, clean taste
Lactic	Medium firmness, slightly off white, tangy taste

CONCLUSION

In conclusion, the results of the mascarpone making experiment show that using vinegar gives the greatest yield and fat recovery. Citric acid was extremely close to having the greatest yield, differing by less then 1% compared to vinegar. It was also determined that people preferred the look, taste, and feel or the mascarpone made by citric acid. Perhaps creating a mixture of vinegar and citric acid would produce an overall ideal mascarpone having the highest yield, fat recovery, and desired characteristics. There are many other variables that can still effect how a batch of mascarpone turns out, leaving many more questions about this delicious cheese to be answered, such as using homogenized or unhomogenized cream and milk. However, based on the results gathered from these trials, it seems citric acid is the best choice to be used when wanting to make the perfect batch of mascarpone cheese that looks, good, tastes good, and is a smart choice economically.

REFERENCES

1. Buragas, Amelia. "Mascarpone Brings Decadence to Sweet and Savory Dishes." 25 Nov. 2005. Web. 26 Nov. 2010. <www.cheesemarketnews.com>.

2. "Cheese Making Ingredients Acids." *Global Dairy Cheese Forum*. 2010. Web. 26 Nov. 2010. <www.cheeseforum.org>.

3. Fox, P. F., and McSweeney. *Dairy Chemistry and Biochemistry*. New York: Thomson Science, 1998. Print.

4. Haskell, Patricia, and Vivienne Marquis. *The Cheese Book*. New York: Simon and Schuster, 1964. Print.

5. Jones, Evan. *The World of Cheese*. New York: Alfred A. Knopf, 1976. Print.

6. "Lactic Acid." PURAC. Web. 27 Nov. 2010. <lactic-acid.com>.

7. Ling, Edgar R. *A Textbook of Dairy Chemistry*. 3rd ed. Vol. 1. New York: Philosophical Library, 1957. Print.

8. "Making Mascarpone." E-mail interview. 7 Oct. 2010.

9. "Mascarpone." *BelGioioso Cheese*. BelGioioso Cheese Inc. Web. 28 Oct. 2010. <www.belgioioso.com>.

10. "Mascarpone." *Recipe Land*. Web. 28 Nov. 2010. <recipeland.com>.

11. "Mascarpone." *Wikipedia*. Web. 15 Oct. 2010. <www.wikipedia.org>.

12. Mullan, W.M.A. "Pearson Square or Rectangle." 2006. Web. 30 Nov. 2010. <www.dairyscience.info>.

13. Reinbold, George W. *Italian Cheese Varieties*. Vol. 1. New York: Chas. Phizer &, 1963. Print.

14. Robinson, Richard K. *Dairy Microbiology Handbook*. 3rd ed. New York: John Wiley and Sons, 2002. Print.

15. Simon, Andre L. *Cheeses of the World*. London: Faber and Faber. Print.

16. Smith, Tim. *Making Artisan Cheese*. MA: Quary, 2005. Print

17. Zonnis, Stephanie. "Mmmmm Mascarpone." *The Nibble*. Lifestyle Direct, Inc., 2005. Web. 20 Oct. 2010. <www.thenibble.com>.

APPENDIX 1

Tiramisu Recipe

Ina Garten, Barefoot Contessa 2002

Ingredients

- 6 extra-large egg yolks, at room temperature
- 1/4 cup sugar
- 1/2 cup good dark rum, divided
- 1 1/2 cups brewed espresso, divided
- 16 to 17 ounces mascarpone cheese
- 30 Italian ladyfingers, or savoiardi
- Bittersweet chocolate, shaved or grated
- Confectioners' sugar, optional

Directions

Whisk the egg yolks and sugar in the bowl of an electric mixer fitted with the whisk attachment on high speed for about 5 minutes, or until very thick and light yellow. Lower the speed to medium and add 1/4 cup rum, 1/4 cup espresso, and the mascarpone. Whisk until smooth.

Combine the remaining 1/4 cup rum and 1 1/4 cups espresso in a shallow bowl. Dip 1 side of each ladyfinger in the espresso/rum mixture and line the bottom of a 9 by 12 by 2-inch dish. Pour half the espresso cream mixture evenly on top. Dip 1 side of the remaining ladyfingers in the espresso/rum mixture and place them in a second layer in the dish. Pour the rest of the espresso cream over the top. Smooth the top and cover with plastic wrap. Refrigerate overnight.