

# Development of Cranberry Orange Muffin

Student: Rifqa Dacloush

Professor: Dr. C. Arnold

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## Role and Scientific Principles (Original Recipe)

Following are the ingredients from the original recipe with their roles and scientific principles:

### Buttermilk

- Softening of crumb texture due to the fat content.<sup>2</sup>
- Browning due to the mixture of fat and sugar.<sup>2</sup>
- Emulsification—Proteins in buttermilk act as oil/water interface, aiding in the formulation and stabilization of fat emulsions.
- Solvent, dissolving sugar, baking powder, salt, and flour. <sup>2</sup>
- Hydration for gluten to develop. The proteins glutenin and gliadin must be hydrated for gluten to start developing.<sup>2</sup>
- Source of steam during baking, which helps in leavening.
- Partial gelatinization when liquid binds to starch granules.<sup>2</sup>

### Large whole egg

- Egg yolk act as a tenderizer. The fat coats the glutenin and the gliadin proteins and inhibits gluten development.<sup>5</sup>
- Provides liquid during folding and baking.<sup>2</sup>
- Add color due the four carotenoid pigments (lutein, zeaxanthin, cryptoxanthin, carotene)<sup>2</sup>.
- Lecithin and Lysolecithin in the egg yolk act as an emulsifier.
- Coagulations of the proteins during baking provides structure and reduce tenderness.<sup>2</sup>

### Vegetable oil

- Gives crumbly texture.<sup>6</sup>
- Promotes tenderness in baking. It has hydrophobic action that hinders gluten development. The degree of hindrance depends on many factors including the type, temperate, and amount of fat used along with the method of incorporating the ingredients in the recipe.<sup>2</sup>
- Breaks down the gluten into shorter strands.<sup>6</sup>

### Granulated sugar

- Tenderness: Retards gluten development and starch gelatinization due to its hygroscopic nature. It competes with the proteins in the flour for water in the mixture.<sup>2</sup>
- Sweetener: Sweet monosaccharides are created due to the breakdown of sucrose.<sup>2</sup>
- Browning: Occurs due to the caramelization and the sugar-amine Millard reaction.
- Volume: This happens through gluten retardation and raising the coagulation temperature of the gluten and egg proteins. This gives more time for cell walls to stretch, and volume to increase before coagulation. In addition, when sugar is creamed with fat, air pockets are created. Due to the production of CO<sub>2</sub> during baking, these air pockets expand and give volume.<sup>2</sup>
- Preservative: This is due to its hygroscopic nature (the ability to hold water).<sup>2</sup>

## Leavening

- Air: Some air is trapped in the mixture while folding. It helps in forming cells needed for a light baked product.<sup>2</sup>
- Steam: As water is converted to steam, volume is increased in the baked product.<sup>2</sup>
- Baking Powder: It has the acid salt and the alkaline baking soda needed to produce carbon dioxide for leavening.<sup>2</sup>

## Walnuts

- These nuts are rich in omega 3 fatty acids and were used to add flavor and texture to the final product since they have sweet buttery flavor.

## Vanilla extract

- Improves flavor.

## Salt

- Improve sweetness.<sup>2</sup>
- Tightens gluten structure, allowing the dough to hold carbon dioxide.
- Acts as a preservative.

## Gluten (from all-purpose flour)

Gluten is composed of two proteins, glutenin and gliadin. These two proteins come from the endosperm layer of the glutenous grains, such as wheat, barley, rye, triticale, spelt, and kamut. In this case, the source of the gluten comes from the all-purpose flour that is produced from the wheat grain.<sup>5</sup>

Gluten is a stretchy, springy network of protein molecules that gives the baked products their structure and form. Gluten formation happens when the flour is mixed with water or other liquids.<sup>8</sup>

Prior to hydrating, glutenin and gliadin are tangled strings. They need to be untangled so that gluten gets formed. Once the liquid is added to the flour, the untangling happens. The mixing, kneading, or in the case of muffins, folding ties the proteins together and sew them into a sheet.<sup>8</sup>

When liquid is added to the all-purpose flour, the starch molecules in the flour expand, and glutenin molecules binds to each other to form long curly chains. The mixing, folding, and kneading of the ingredients help the bonding between glutenin. On the other side, gliadin molecules stay in their compact shape in the presence of liquid. This allows for some glutenin portions to slide past each other without sticking together. This helps in sustaining shape during baking.<sup>8</sup>

In the case of making muffins, it is important to use the gentle folding technique, and to fold just about when all the ingredients are mixed. Leaving some clumps is actually desirable. Overfolding ought to be avoided in order to end up with a soft tender muffin.

## Roles and Scientific Principles (Modified Recipe)

### Liquid Replacement

Half of the buttermilk that was required by the original recipe was replaced with a 1/3 cup of 2% plain yogurt to provide smooth texture, moisture, and richness. Yogurt is a delicious, creamy, cultured milk. It is easy to digest since the natural occurring bacteria convert lactose sugar to lactic acid. In addition, it is a great source of probiotics and prebiotics, which help in digestion, gut health, and gut inflammation.<sup>1</sup>

The other half of the buttermilk was replaced by 1/3 cup of fresh orange juice. Since orange juice is a liquid, many of the roles that were mentioned under buttermilk above apply to orange juice. In addition, orange juice reduces the pH of the muffin mix, modifies the solubility of gluten, and alters the flavor by giving it a tangy fruity one.<sup>2</sup>

### Oil Replacement

The oil was replaced in the recipe to decrease the caloric intake and boost the recipe's nutrients. The prune puree replaced oil to bind the ingredients together, give a creamy texture, moisturize, tenderize, and to give form and structure that is similar to the role that fat plays. The pectin in the prune puree helps in gelling, thickening, and stabilizing.<sup>(3, 4)</sup>

### Flour Replacement

The original recipe called for one cup of all-purpose flour. In the modified recipe, it was replaced by 1/2 cup stone-ground whole-wheat flour, and 1/2 cup of blanched almond flour. There are 13 grams of protein in one cup of all-purpose flour. The 1/2 cup of stone-ground whole-wheat flour has only 8 grams of protein.<sup>5</sup> The higher the protein content in a wheat-based flour the stronger the gluten network. Almond flour is a gluten-free flour, and it contains the healthy monounsaturated fatty acids (MUFA) and vitamin E. There was less gluten present in the developed recipe due to the reduction of wheat-based flour, and the increase of fiber and fat from the whole wheat and almond flours. The result was an enhanced texture, flavor, and nutrient content.

### Orange Rind

It was added to improve flavor, texture, and adds a little bit of color and fiber.

### Cranberries

They were added to give a sweet-sour flavor, moisture, texture, body, color, nutrients, and fiber. Also, the pectin in cranberries helps in gelling, thickening, and stabilizing during baking.

## Cornstarch

The starch was used to absorb water and reduce the moisture in the muffin. The starch helps in thickening and binding as well, and the result is a good muffin structure with the right moisture level. <sup>(3,4)</sup>

## Butter

Since I omitted all the oil, I added a little bit of butter along with some sugar and nuts to give a muffin topping that is crispy, crunchy, and with distinctive rich flavor.<sup>1</sup>

## Walnuts

They were added to the top of the muffin before baking, and I opted for using the raw version to avoid burning. Walnuts have high content of oil. According to the Mayo clinic, “walnuts, are a source of omega-3 fatty acids, which lowers triglycerides, improves vascular health, helps moderate blood pressure and decreases blood clotting.”<sup>7</sup>

## Nutrient Density

It is the measure of nutrients in food item(s) in relation to the provided calories. The more nutrients that are present in food item(s) in comparison to the total calories, the higher the nutrient density in the food item(s). For example, a breakfast containing cereal, fruit, egg, and sausage provides many more nutrients than a breakfast that contains two doughnuts. Even though both breakfasts give more or less the same calories, the first breakfast contains more protein, fiber, vitamin D, calcium, iron, and potassium.<sup>23</sup>

## Nutrient Density (Modified Recipe)

The following summarizes the changes in nutrient density in the modified recipe. The complete nutrient analysis can be found in Appendix B.

- A much higher percent daily value of fiber, 13% in comparison to only 4% in the original recipe. This is mainly due to the flour replacement (combination of whole wheat flour

and blanched almond flour), the oil replacement (prune puree), and adding the cranberries. Health benefits of fiber include preventing constipation, maintaining a healthy weight, and lowering the risk of diabetes, heart disease and some types of cancer.<sup>13</sup>

- A much higher percent of the daily value of antioxidants, the percent daily value of vitamin C is 9% compared to 1% in the original recipe. This is mainly due to the addition of cranberries, prune puree, and orange juice. Vitamin C plays an important role in forming blood vessels, cartilage, muscle, and collagen in bones. Also, it is necessary to the body's healing process as well as for protection against free radicals (molecules produced during catabolism, and upon exposure to radiation from the sun, X-rays, and other sources.) Free radicals may have a role in heart disease, cancer, as well as others. In addition, vitamin C helps the body absorb iron.<sup>14</sup>
- A higher percent daily value of magnesium, 10% in comparison to 5% in the original recipe. Magnesium has important body functions. These include supporting muscle and nerve function, and energy production. persistent and recurring low magnesium levels may increase the risk of high blood pressure, heart disease, type 2 diabetes, and osteoporosis.<sup>15</sup>
- A higher percent daily value of zinc, 8% in comparison to 6% in the original recipe. Zinc helps in the body's immune system and metabolism. Also, it plays a major role in wound healing, and sense of smell and taste.<sup>16</sup>
- A lower total fat, 9% versus 10% in the original recipe. A lower cholesterol, 11% versus 13% in the original recipe. High levels of cholesterol increase the risk of heart disease. In addition, it can increase fatty deposits in the blood vessels, that can suddenly break off and to form a clot that causes a heart attack or a stroke.<sup>17</sup>
- A lower sodium level, 4% versus 10% in the original recipe. Sodium can raise blood pressure, which is a major risk for heart attack, stroke, heart failure, and dementia.<sup>18</sup>
- A higher iron level, 8% in the modified vs. 4% in the original. Iron is needed to generate normal red blood cells to keep the body healthy.<sup>19</sup>
- A higher thiamin (B1) level, 12% versus 6% in the original recipe. Vitamin B1 helps the body in generating energy from nutrients, and important for function, growth, and development of the cells.<sup>20</sup>
- A higher Niacin, 9% in the modified recipe versus 3% in the original recipe. Vitamin B3 keeps the nervous system, digestive system, and skin healthy.<sup>20</sup>

- A higher B6, 8% in the modified recipe versus 4% in the original recipe. Pyridoxine (B6) is key for normal brain development, and healthy nervous and immune systems.<sup>22</sup>

## Methodology

### Written Summary

This recipe was developed over a two-week period. It started by following a basic muffin recipe, and was followed by eight modifications before the desired result was reached. To give a more profound taste to the recipe, buttermilk was substituted with 2% plain yogurt and freshly squeezed orange juice. To reduce total calories and to increase nutrient density, prune puree replaced vegetable oil. To increase the fiber and to give the final product a more wholesome profile, all-purpose flour was substituted with a combination of two flours (stone-ground whole-wheat flour and blanched almond flour.) To add additional nutrients, flavors, and to play with the combination of cranberries and orange juice, frozen cranberries were added to the recipe. The proportion of frozen cranberries was reduced to remove extra moisture that was present in the muffin. Then, corn starch was added to reduce the extra moisture that was still in the muffin. Finally, the muffin topping was added to give the muffin a crispy, crunchy texture and sweet taste.

### Listing of Changes

Date	Recipe (1–5-word description)	Modification (provide specific portion sizes)	Rationale
3/4/2021	#1) Original	None	To begin recipe development
3/4/2021	#2) Substituted buttermilk with 2% plain yogurt, and fresh orange juice	Used: <ul style="list-style-type: none"> <li>• 1/3 cup of 2% plain yogurt and</li> <li>• 1/3 cup of fresh orange juice.</li> </ul> Instead of: <ul style="list-style-type: none"> <li>• 2/3 cups buttermilk.</li> </ul>	To give some tangy, citrusy, and creamy rich taste and flavor, and to give a nutrient boost of protein, carbohydrates, along with some fat, calcium, and probiotics. <sup>10</sup>
3/4/2021	#3) Substituted vegetable oil with prune puree.	Used: <ul style="list-style-type: none"> <li>• 2 oz. of prune sauce.</li> </ul>	To reduce the fat in the recipe and improve the nutrient



		<p>Instead of:</p> <ul style="list-style-type: none"> <li>• 3 Tbsp. oil.</li> </ul>	<p>density in the recipe. Prune is rich in potassium, fiber, and antioxidants.<sup>9</sup></p>
3/4/2021	#4) Substituted all-purpose flour with a combination of two flours (stone-ground whole-wheat flour and blanched almond flour)	<p>Used:</p> <ul style="list-style-type: none"> <li>• ½ cup of stone-ground whole-wheat flour and</li> <li>• ½ cup of blanched almond flour.</li> </ul> <p>Instead of</p> <ul style="list-style-type: none"> <li>• 1 cup of all-purpose flour.</li> </ul>	<p>To give the final product a more wholesome profile. Both flours are higher in protein and fiber content than all-purpose flour.<sup>11</sup></p>
3/4/2021	#5) Added frozen cranberries and orange zest	<p>Added:</p> <ul style="list-style-type: none"> <li>• 1 cup chopped frozen cranberries.</li> <li>• 3 Tbsp. fresh orange zest.</li> </ul>	<p>To add additional nutrients (fiber, and vitamin C).<sup>12</sup> To play with the combination of cranberries and orange juice.</p>
3/11/2021	#6) Repeated last recipe produced from last week.	<ul style="list-style-type: none"> <li>• No modifications here.</li> </ul>	<p>To have a reference point for additional modifications.</p>
3/11/2021	#7) Reduced frozen cranberries.	<ul style="list-style-type: none"> <li>• Removed ¼ cup.</li> </ul>	<p>To reduce moisture in the muffin.</p>
3/11/2021	#8) Added cornstarch	<ul style="list-style-type: none"> <li>• Added 1 tsp.</li> </ul>	<p>To reduce moisture in the muffin.</p>
3/11/2021	#10) Changed the muffin topping from plain nuts to crunchy, sweet topping.	<ul style="list-style-type: none"> <li>• Added 1 Tbsp. grass fed butter.</li> <li>• 2 tsp. ground stone whole wheat flour.</li> <li>• 1 Tbsp. Sugar</li> <li>• ¼ cup chopped walnuts (raw.)</li> </ul>	<p>To create an appealing look to the muffin, and to give some crispy, crunchy, and sweet taste to the muffin.</p>

## Results

## Written Summary

At the end of every week, three muffins were saved from every modified batch for three different evaluators (self and two family members) to taste and provide assessment. Each evaluator received a muffin from each batch, and a form to conduct the evaluations. Evaluators had to judge and give feedback on the following quality characteristics (appearance, flavor and aftertaste, texture and consistency, odor, and overall quality) for every muffin they tasted. The feedback included a numeric scoring system that spanned from 1 being the worst to 7 being the best. Also, next to each score given for each quality characteristic, evaluators were supposed to give few comments to justify the score given.

For the final recipe, there were 4 evaluators (self, and three family members.) Each evaluator got a muffin from the final batch, and a form to fill. Evaluators had to judge and give feedback for the same quality characteristics mentioned in the above form. However, this time the feedback included a numeric scoring system that spanned from 1 being the worst to 9 being the best. Also, evaluators were supposed to give few comments to justify the score given for each category.

## Results in Table Format

Quality characteristic rating and overall acceptability of cranberry orange muffin as rated by four evaluators

<b>Score:</b>	<b>Odor:</b>	<b>Flavor:</b>	<b>Texture and Consistency:</b>	<b>Appearance:</b>	<b>Overall Eating Quality:</b>
7	1 – (25%)	1 – (25%)	0 – (0%)	0 – (0%)	0 – (0%)
8	0 – (0%)	2 – (50%)	2 – (50%)	1 – (25%)	3 – (75%)
9	3 – (75%)	1 – (25%)	2 – (50%)	3 – (75%)	1 – (25%)
<b>Mean +/- S.D.</b>	8.5 +/- 1.0	8.0 +/- 0.8	8.5 +/- 0.6	8.8 +/- 0.5	8.3 +/- 0.5

Key:

<b>Score</b>	<b>Meaning</b>
9	Like Extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

## Conclusions and Applications

The calculated means and standard deviations for the various evaluation categories showed high levels of satisfaction with the final cranberry orange muffin with average results falling between the top two ratings of 'like very much' and 'like extremely'.

While I would have liked to have a larger number of evaluators, nonetheless, given the small sample size of four ( $n=4$ ) provided valuable information. A statistical Student's t-distribution analysis was conducted on the collected data and the following 90 and 95 percent confidence intervals were calculated for the population mean:

<b>Evaluation Category</b>	<b>90% Confidence Interval for <math>\mu</math></b>	<b>95% Confidence Interval for <math>\mu</math></b>
Odor	(7.3 – 9.7)	(6.9 – 10.1)
Flavor	(7.1 – 8.9)	(6.7 – 9.3)
Texture and Consistency	(7.8 – 9.2)	(7.5 – 9.5)
Appearance	(8.2 – 9.4)	(8.0 – 9.6)
Overall Eating Quality	(7.7 – 8.9)	(7.5 – 9.1)

The results showed that the lower bounds of the population means for the odor and flavor categories were predicted to be greater than a score of 7 (like moderately) while texture and consistency, appearance and overall eating quality categories had even higher lower bounds of around 8 (like very much). These results demonstrate that the cranberry orange muffin had a high acceptability level in all categories.

Some of the positive comments that were received regarding the cranberry orange muffin included:

- Very flavorful with sweet, sour, citrusy, and earthy nutty taste.
- Very attractive as well as tasty, and the crunchy top gives it an extra dimension.
- The combination of cranberry fruit and orange juice go very well together and makes it a perfect Fall muffin.

One suggestion was to try to replace the cranberries with raspberries for a Spring version of the muffin, and maybe use pecans instead of walnuts for the topping of the muffin.

It is important for food and nutrition professionals to understand and conduct the recipe development process so that they end up with a product that has an overall high acceptability. Following are the main lessons that I have learned from the development of the cranberry orange muffin:

- Adding new ingredients to an existing basic recipe changes many aspects of the recipe. While it could improve certain quality characteristics of the product, it might worsen others. For example, in the case of developing the cranberry orange muffin, while the flavor, the odor, and the appearance were improved, the structure had worsened. I had to try different things to reach the correct moisture level. Eventually, reducing the cranberries quantity, and adding cornstarch were the two things that created the right texture and consistency.
- While It is important to plan all the modifications that you want to do beforehand, it is also important to be able to come up with different ones while developing the recipe depending on the results you are getting, and the final product that you are trying to produce. Keep in mind that the development process may take several trials to reach the desired product.
- Also, it is important to take into consideration the feedback from the evaluators during the product development in order to improve your product and to create one that your clients desire.
- Any recipe can be tweaked so that it will be applicable to certain special groups. For example, gluten containing recipes can be changed to become gluten free so that people with celiac disease and gluten intolerance can enjoy.

## References

1. Katie McKee. The Science Behind Cooking with Dairy. Dairymax.org. <https://www.dairymax.org/blog/science-behind-cooking-dairy#:~:text=Baking%20cakes%20or%20other%20sweets,gluten%20and%20a%20softer%20texture>. Published Feb 5, 2016. Accessed May 7, 2021.
2. McWilliams. M. Dimensions of Baking. Eighth ed. Foods Experimental Perspectives. New Jersey: Pearson Education, Inc.; 2017. Chapter 14.
3. Science Direct. Fat Substitutes. <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/fat-substitute>. Accessed May 7, 2021.
4. Bakerpedia.com. Pectin. <https://bakerpedia.com/ingredients/pectin/>. Accessed May 7, 2021.
5. Margaret Hill. Attack of the Gluten. American Chemical Society. <https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2011-2012/gluten.html>. Published February 2012. Accessed May 7, 2021.
6. Institute of Food Science and Technology. Fats and Oils: Shortening. <https://www.ifst.org/lovefoodlovescience/resources/fats-and-oils-shortening#:~:text=Examples%20of%20fat%20used%20as,stands%E2%80%9D%20hence%20the%20term%20shorteners>. Accessed May 7, 2021.
7. Mayo Clinic Health System. Maximize memory function with a nutrient-rich diet. <https://www.mayoclinichealthsystem.org/hometown-health/speaking-of-health/maximize-memory-function-with-a-nutrient-rich-diet#:~:text=Healthier%20fats,-Olive%20oil%20provides&text=Nuts%2C%20like%20the%20walnut%2C%20are,pressure%20and%20decreases%20blood%20clotting>. Published October 7, 2020. Accessed May 7, 2021.
8. Serious Eats. What Is Gluten? The Science Behind Great Dough. <https://www.serious-eats.com/what-is-gluten-free-bread-dough-pasta>. Accessed May 7, 2021.
9. Barbie Cervoni. Prune Nutrition Facts and Health Benefits. Very Well Fit. <https://www.verywellfit.com/prunes-nutrition-facts-calories-and-their-health-benefits-4114558>. Accessed May 7, 2021.
10. Stacey Hugues. The Best Yogurt for People with Diabetes. Very Well Health. <https://www.verywellhealth.com/greek-yogurt-nutrition-1087149>. Accessed May 7, 2021.
11. Malia Frey. Flour Nutrition Facts and Health Benefits. Very Well Fit. <https://www.verywellfit.com/flour-nutrition-facts-calories-and-health-benefits-4119166>. Accessed May 7, 2021.
12. Laura Dolson. Cranberry Nutrition Facts and Health Benefits. Very Well Fit. <https://www.verywellfit.com/carb-counts-for-cranberries-2241782>. Accessed May 7, 2021.
13. Mayo Clinic. Dietary fiber: Essential for a healthy diet. <https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/fiber/art-20043983>. Published January 6, 2021.
14. Mayo Clinic. Vitamin C. <https://www.mayoclinic.org/drugs-supplements-vitamin-c/art-20363932>. Published November 7, 2020.

15. [Katherine Zeratsky](https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/expert-answers/magnesium-supplements/faq-20466270#:~:text=Magnesium%20plays%20many%20crucial%20roles,type%20%20diabetes%20and%20osteoporosis). I've heard that magnesium supplements have health benefits. Should I take one? Mayo Clinic. <https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/expert-answers/magnesium-supplements/faq-20466270#:~:text=Magnesium%20plays%20many%20crucial%20roles,type%20%20diabetes%20and%20osteoporosis>. Published December 17, 2019.
16. Mayo Clinic. Zinc. <https://www.mayoclinic.org/drugs-supplements-zinc/art-20366112>. Published November 17, 2020.
17. Mayo Clinic. High Cholesterol. <https://www.mayoclinic.org/diseases-conditions/high-blood-cholesterol/symptoms-causes/syc-20350800>. Accessed May 7, 2021.
18. Jason Howland. Mayo Clinic Minute: Reduce salt to improve heart health. <https://newsnetwork.mayoclinic.org/discussion/mayo-clinic-minute-reduce-salt-to-improve-heart-health/>. Published February 28, 2020.
19. Mayo Clinic. Iron Supplement (Oral Route, Parenteral Route). <https://www.mayoclinic.org/drugs-supplements/iron-supplement-oral-route-parenteral-route/description/drg-20070148>. Accessed May 7, 2021.
20. Mayo Clinic. Thiamin. <https://www.mayoclinic.org/drugs-supplements-thiamin/art-20366430>. Published November 14, 2020.
21. Mayo Clinic. Niacin. <https://www.mayoclinic.org/drugs-supplements-niacin/art-20364984#:~:text=It%20helps%20keep%20your%20nervous,from%20the%20food%20they%20eat>. Published November 12, 2020.
22. Mayo Clinic. Vitamin B-6. [https://www.mayoclinic.org/drugs-supplements-vitamin-b6/art20363468#:~:text=Vitamin%20B%2D6%20\(pyridoxine\),chickpeas%2C%20bananas%20and%20fortified%20cereals](https://www.mayoclinic.org/drugs-supplements-vitamin-b6/art20363468#:~:text=Vitamin%20B%2D6%20(pyridoxine),chickpeas%2C%20bananas%20and%20fortified%20cereals). Published February 3, 2021.
23. Whitney E, Rolfes S. An Overview of Nutrition. Fifteenth ed. *Understanding Nutrition*. Boston, Ma USA: Cengage Learning, Inc. 2019,2016. Chapter one.