The History of Food Fortification in the United States

In the 1920s, the widespread processing of foods began (Adams, 2011). Gradually, Americans realized by processing, nutrient loss occurred. In 1928, there were nearly 7,000 deaths due to pellagra, which is caused by a deficiency of vitamin B3, also known as niacin. Pellagra was one of the top ten leading causes of death in the southern part of The United States in the late 1920s, along with beriberi (due to deficiency in vitamin B1, known as thiamin) and iron-deficiency anemia, which was also becoming widespread, thus a change needed to happen.

Food fortification, which is the addition of micronutrients to food, is an effective way to prevent nutritional deficiencies and the diseases associated with them (Bishai and Nalubola, 2002). Health professionals began realizing that adding thiamin to flour would prevent beriberi, the disease associated with its deficiency, because one-fourth of the American diet relied on refined flour (Bishai and Nalubola, 2002). In 1938, the American Medical Association issued a statement recommending fortification (starting with thiamin) for staple foods like flour, which began the efforts to enrich grains. After the recommendation, some manufacturers voluntarily began to enrich their bread with high-vitamin yeast (Adams, 2011). However, in 1939, a report found that with the current processing procedures, Americans were only getting one-eleventh of the thiamin provided by previous methods. It was then decided to add all synthetic B Vitamins that were available to grains, which added niacin with the thiamin that was already added. Iron was also added to this group, because of how common iron deficiency was at this time due to individuals not consuming enough nutrients during this time period.

It was not until 1941 that there was an actual line drawn between what was considered enriched and what was considered unenriched (Adams, 2011). By this time, World War II was in full swing. The British army decided to produce only enriched flour claiming it helped their

soldiers fight for longer periods of time and recover faster. Upon hearing this, the United States decided to do the same, using army ad campaigns to promote the enrichment of grains. The ads told individuals that if they had enriched grains in their diet it would help restore energy and make them more suitable and stronger for war. This advertising (Figure 1), although creative, was not necessarily effective. By 1942, the nation's enrichment of flour had only increased to 40% (Bishai and Nalubola, 2002). The problem was not that consumers did not want the fortified grains, but that they were not being produced as frequently as the unenriched grains.

Figure 1: Advertisement for Fortified Donuts

It was harder for smaller manufacturers to produce enriched flour, because they would not be able to compete with larger, more well-known brands in terms of prices (Bishai and Nalubola, 2002). Small manufacturers wanted to wait until there was an absolute demand for these fortified products so that buyers would pay the additional costs. As this change in product

did not become as popular or profitable as expected, the idea of enriched products began to disintegrate, and producers decided to revert to their original products. Nutritionists began to seek government help for this problem. This led to influential organizations, such as the Army, making the switch to purchasing only enriched flour. Several states also created laws requiring grains to be enriched. By 1950, these mandates were implemented in 26 out of 48 states and 3 territories.

Seeing that avitaminosis was no longer a major public health threat and that enrichment of grains was working, many companies decided to fortify their products anyway in the early 1960s, even without mandatory enrichment laws (Park et al., 2001). While enrichment was now a regular process for companies, it was restricted to bread and cereal grains, which presented new health concerns. On December 2, 1969, the "White House Conference on Food, Nutrition, and Health" was held, addressing the issues of malnutrition and hunger that were still prevalent in the U.S., despite these enrichment changes. Several new recommendations were made for fortification which recommended all wheat flour, corn flour, and milled rice be enriched according to federal standards. The goal was to lower the level of hunger and malnutrition by allowing enrichment of grains to reach each socioeconomic level. While the 1960s increased the amount of grains being fortified, there were still a few categories left untouched, including farina and noodle production.

In the 1970s, several states enacted laws to cover all remaining grain products which required them to meet federal fortification standards, while other states changed the mandatory enrichment laws to optional (Park et al., 2001). On top of this, from 1970 to late 1979, there were debates about raising the iron enrichment levels in flour and breads to meet the needs of all Americans, by grouping men, women, and children's iron needs together. The federal iron

enrichment standards at that time had a range of requirements that allowed companies to choose how much they fortified, within limits. Opponents argued that higher iron supplementation could result in toxicity and iron storage disorders. In October of 1979, the FDA concluded that a single-level standard of 20 mg of iron per pound of flour would be set, so that it was sufficient for all people, but not too high to cause more health problems, such as iron overload or hemochromatosis (USFDA, 2019).

The guidelines for fortification were finalized by the FDA in 1980, but states continued to convert their policies from mandatory to optional (Park et al., 2001). As of 1988, only 28 states adhered to the FDA's policies in some way with mandatory enrichment laws. This changed in 1990 when President George H.W. Bush signed the Nutrition Labeling and Education Act, which prevented states from having their own enrichment standards for products in interstate commerce. Since products were required to be enriched, there needed to be some type of consistency in the enrichment levels. In 1998, the FDA set the current enrichment standard, defining the levels of nutrients needed for a grain to be considered enriched. The nutrients that are measured are the B vitamins, more specifically, niacin, thiamin, and riboflavin, as well as folic acid and iron (Table 1). Fortification has caused a significant decrease in neural tube defects, spina bifida, anencephaly, beriberi, and the elimination of pellagra in the United States (Adams, 2011; Bishai and Nalubola, 2002).

Table 1: Description of nutrients added to grains and the diseases prevented

Nutrient	Fortification Date	Disease	Symptoms of deficiency
Thiamin	1942	Beriberi	Loss of feeling in hands and feet, decreased muscle function, mental confusion
Niacin	1942	Pellagra	Sores on skin, delusion, loss of appetite, weakness
Iron	1942	Anemia	Fatigue, cramps, dizziness, shortness of breath
Riboflavin	1943	Ariboflavinosis	Cracks in skin and at corners of the mouth, purple and inflamed tongue, lip fissures
Folic Acid	1998	Birth defects	Neural tube defects, spina bifida, anencephaly

Nutrient Standards

The FDA set the standards for thiamin, riboflavin, niacin, iron, and folic acid per 100 calories (Table 2). More of the nutrient may be added to foods, but only to a point where excessive intake of the nutrient will not occur (USFDA, 2019). These nutrients are not required to be added to foods replacing traditional items e.g. gluten-free products, but they are allowed to be added. Adding a nutrient to food is only appropriate when it is physiologically available in the product but has been reduced or depleted from processing.

Table 2: FDA standards for nutrient fortification of B-vitamins and Iron per 100 calories

Thiamin	.08mg
Riboflavin	.09mg
Folate	20mcg
Niacin	1mg
Iron	.9mg

Grains in the Diet

In the United States, the diet revolves around grains. Out of a 2,000 calorie per day diet, 6 ounces of grains should be consumed, which accounts for about 30% of our daily intake (Dietary Guidelines, 2015). The consumption of grains is associated with better health, due to the large amounts of vitamins and fiber in them. Whole grain consumption reduces the risk of heart problems, supports healthy digestion, and is associated with maintaining a healthy weight (Lin and Yen, 2007; United States Food and Drug Administration, 2019). These whole grains include whole-wheat bread, cereals, crackers, oatmeal, quinoa, and brown rice.

What is Gluten?

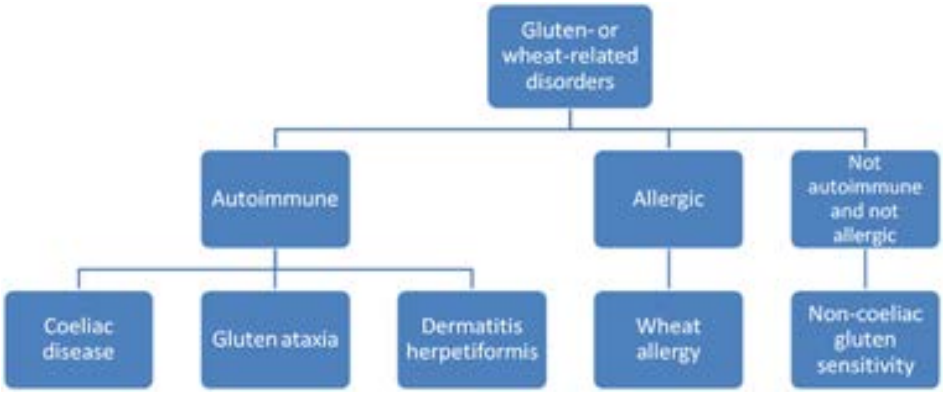
The main storage protein in wheat grains is gluten, which consists of gliadin and glutenin (Biesiekierski, 2017). The two proteins are bound together by very strong covalent and non-covalent forces creating a matrix, giving gluten its unique properties. Gluten holds things together, allowing food to hold its shape. Gluten is found in wheat, rye, and barley containing products, as well as processed foods where it is added to increase moisture retention and to improve texture.

Gluten Related Disorders

There are a number of disorders that are triggered by consumption of gluten including celiac disease, gluten ataxia, dermatitis herpetiformis, wheat allergies, and non-celiac gluten sensitivity (Figure 2)(Biesiekierski, 2017). Celiac disease is the most commonly studied out of these diseases. Although only 1% of the population is diagnosed with the disease, many healthcare professionals believe it is underdiagnosed. (Cooper, 2012; Newberry 2017). In the case of celiac disease, gluten proteins trigger an immune response that causes mucosal inflammation in the gut, destroy the villi in the small intestine, and increase gut permeability (Biesiekierski, 2017). This immune response may cause multiple gastrointestinal problems

including diarrhea, cramping, and nausea. The only treatment for gluten related disorders and allergies is a gluten free diet.

Figure 2: Gluten-related disorder classification (Biesiekierski, 2017).



The Gluten Free Diet

There are many foods individuals on a gluten-free diet need to avoid including: wheat, rye, barley, and sometimes oats (Melini, V and Melini, F, 2019). These grains are found in most bread-type products, but can also be hidden in foods. Foods such as marinades, sauces, dressings, gravies, stuffing, and seasonings often unexpectedly contain gluten. There are a variety of processed foods that contain gluten as well, like processed meat, vegetarian meat substitutes, and seafood. Fried foods may contain gluten or may be fried in a place where an option with gluten was cooked, which would result in cross-contamination. In the United States, the Food and Drug Administration allows up to 20ppm of gluten to be detectable in foods that are labelled gluten free.

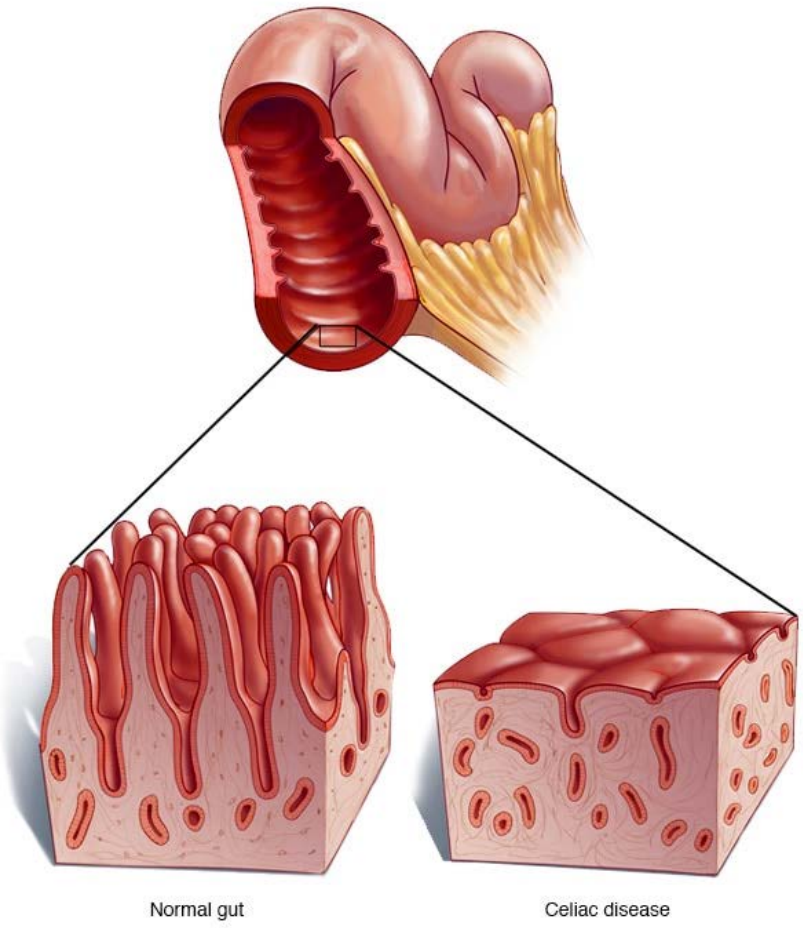
Individuals on a gluten free diet must be very careful with what they consume and may not be able to go out to eat out of fear of cross-contamination, which may trigger an immune response (Biesiekierski, 2017). Luckily, with the rise of individuals avoiding gluten, there are now many substitutes readily available in supermarkets and restaurants. Not only is gluten in foods, but it is often found in beauty products and medications.

People on gluten free diets may be at risk for nutrient-related deficiencies, since flours used in gluten free products may not be fortified (Newberry et al., 2017; Diez-Sampedro, 2019). Health complications associated with gluten related disorders or allergies may also present deficiency risk. Several studies have found that individuals on a gluten free diet are not consuming adequate amounts of calcium, vitamin D, magnesium, zinc, B-vitamins, iron, and fiber.

Supplementation for gluten-related disorders.

Supplementation may not be beneficial for an individual recently diagnosed with celiac disease due to damage in the small intestine (Jones, 2017). The immune response triggered by consumption of gluten destroys the lining of the small intestine (Figure 3). The villi may grow back after an individual becomes healthy again and stops consuming gluten, which would allow for nutrients to be absorbed (Dennis, 2012; Jones, 2017). Foods high in nutrients are recommended for individuals with gluten-related disorders, especially if they are recovering from damage to the small intestine. If the individual is unable to get adequate nutrients from the diet, supplementation would be recommended.

Figure 3: Normal Gut vs. Celiac Gut (Mayo Clinic, 2019).



Who is most at risk for celiac disease?

Everyone is at risk for this genetic autoimmune condition, but there are factors that can increase an individual's risk (Mayo Clinic Staff, 2019). Individuals with a family history of celiac disease are 5-10% more likely to be diagnosed with the disease. Having an autoimmune disease such as a thyroid disease or type 1 diabetes causes individuals to be more likely to develop another autoimmune disease like celiac disease. Traumatic events such as surgery, pregnancy, childbirth, severe infections, and emotional stress may cause celiac disease to become active in an individual.

Gluten-free Social Media Influencers

The recent rise in popularity of the gluten free diet most likely stems from popular media and celebrity endorsements (Newberry et al., 2017). Before the mid-1900s, the gluten free diet was rarely a topic of conversation. It is now a focus for magazines, blogs, best-selling books, and even television shows. To better understand the forces encouraging eating gluten-free, despite having no disease, I reviewed 10 gluten related blogs including those from authors, doctors, dietitians, sports, recipe suggestions, and lifestyles of a gluten-free individuals.

Table 3: Gluten-related blogs reviewed for this project

GoodForYouGlutenFree.com	AllysonKramer.com
WhattheForkFoodBlog.com	GlutenFreeMike.com
AntiWheatGirl.com	GlutenFreeTravelblog.typepad.com
CeliacandtheBeast.com	Eastewart.com
RootCauseMedical.weebly.com	WheatFreeLivingandMe.blogspot.com

Many people making the switch to a gluten free diet do it based on social media testimonials of people claiming eating gluten free has “cured” a multitude of health problems (Newberry et al., 2017). For example, William Davis, the author of the book *Wheat Belly* argues that gluten triggers immune responses that are correlated to obesity, cardiovascular diseases, and diabetes (Davis, 2014; Newberry et al., 2017). He says a “wheat belly” shows an accumulation of fat resulting from consuming foods such as gluten that trigger insulin, which is a fat storage hormone.

Elite athletes have been promoting gluten free diets claiming that it improves their performances, decreases inflammation, lowers their chances of illnesses, and improves their body composition (Lin et al., 2013; Newberry et al., 2017). Popular celebrities also promote gluten free diets. Kourtney Kardashian, for example, put her entire family on gluten-free diets

stating that they did not have issues when eating dairy and gluten, but she believe it would increase their quality of life (Manzziotta, 2016). This push for gluten-free diets from influential individuals has piqued an interest for many about the gluten-free lifestyle.

Most blogs consisted of gluten free recipes from individuals who avoid gluten, but one blogger who was actually diagnosed with celiac disease spoke of the struggles she found with other individuals who claim to be gluten free (Finke, 2017). She has experienced situations with gluten free friends who will order an entree that is gluten free and then a beer that is not. This is particularly frustrating as she has to eat gluten free and be free of contamination to live a healthy life. Individuals who pick and choose when they want to be gluten free confuse restaurant workers, causing them to not take the allergy itself so seriously, which can be life threatening for people like her. Finke believes that being gluten free should not be a fad; it should be for people who have to commit to it for allergies of other health reasons.

Overall, the switch to a gluten free diet has been advertised to help individuals lose weight, boost energy, and increase health, but to health care workers this does not make much sense (Strawbridge, 2020). A professor at Harvard Medical states that many individuals who go gluten free will experience little to no benefit from the change. The primary use of the diet is for therapeutic benefits, like in patients with celiac disease.

Summary

The start of grain fortification began 100 years ago in the 1920s, which resulted in increased nutritional standards in foods and a decrease in nutrient related diseases (Rielly, 2016). As individuals learned more about the nutrients in food, they also became more educated about what else made up grain products. With the discovery that gluten can cause many unwanted symptoms in individuals, we are now able to treat these diseases with a gluten free diet. Due to the growth of popularity in the gluten free diet, more people are eating gluten free products than

ever before. The growth of celiac disease, however, is disproportionate to the increase in growth of the gluten free food industry. The demand for gluten free products comprises a market share of $15 billion worldwide, and that number is still rising (Newberry et al., 2017). Gluten-free foods are able to be sold at three times the price of the traditional options even with fewer nutrients added.

Nutrient content and price of gluten containing compared to gluten free products:

To understand the nutrient content of gluten free products compared to gluten containing products, I looked at the nutrition facts label of foods individuals commonly consume to reach their daily grain requirement such as bread, pasta, cereal, and frozen foods. Information was gathered from the Whole Foods and Walmart websites, which show individual nutrition facts labels for each product. The vitamins primarily compared are thiamin, riboflavin, niacin, folate, and iron, because of the standards for traditional products set by the FDA. The price of the gluten free products and gluten containing products were also compared to demonstrate that gluten free items are sold at significantly higher prices, while having less nutrients than regular products.

Table 4: Comparison of the price and nutrient content in gluten free and non-gluten free bread

Brand	Thiamin	Riboflavin	Niacin	Folate	Iron	Other:	Price
Nature's Own Honey Wheat	.2mg	.1mg	1.3mg	55mcg and 30mg folic acid	1mg	Calcium 50 mg	$3.49
Canyon Bakehouse Whole Grain (GF)	0mg	0mg	0mg	0mcg	0mg	Calcium 10 mg, Potassium 51 mg	$7.99
Udi's Soft and Hearty Whole Grain (GF)	0mg	0mg	0mg	0mcg	.4 mg	Calcium 50 mg	$4.99
Rudi's Multigrain (GF)	0mg	0mg	0mg	0mcg	.6mg	Calcium 30 mg, Potassium 50 mg	$5.79

Table 5: Comparison of the price and nutrient content in gluten free and gluten containing pasta

Brand	Thiamin	Riboflavin	Niacin	Folate	Iron	Other	Price
De Cecco Linguine Pasta	.5mg	.2mg	3.5mg	186mcg and 111mcg Folic Acid	1.7mg	Calcium 15mg, Potassium 139mg	$2.99
Ancient Harvest Supergrain Spaghetti Pasta (GF)	0mg	0mg	0mg	0mcg	1.75mg	None listed	$3.69
Jovial 100% Organic Whole Grain Capellin Brown Rice Pasta (GF)	0mg	0mg	0mg	0mcg	7g	None listed	$4.19
Manini's Spaghetti pasta (GF)	0mg	0mg	0mg	0mcg	2.2mg	Vitamin D .7mcg, Calcium 60 mg, Potassium 240mg	$6.99

Table 6: Comparison of the price and nutrient content in gluten-free and gluten containing cereals

Brand	Thiamin	Riboflavin	Niacin	Folate	Iron	Other	Price
365 Everyday Value Raisin Bran Cereal	1.1mg	0mg	3.2mg	60mcg and 35mcg Folic Acid	8mg	Potassium 340mg, Pantothenic acid 1mg, Phosphorus 230mg, Magnesium 95 mg	$3.49
Arrowhead Mills Organic Maple Buckwheat Flake (GF)	.1mg	.1mg	2.2mg	0 mcg	.9mg	Potassium 130 mg	$6.29
Cascadian Farm Organic Honey Vanilla Crunch Cereal (GF)	0mg	0mg	0mg	0mcg	1.3mg		$3.99
Nature's Path Organic Crunchy Sunrise Honey Cereal (GF)	0mg	0mg	0mg	0mcg	.6mg		$5.79

Table 7: Comparison of the price and nutrient content in gluten-free and gluten containing frozen pizza

Brand	Thiamin	Riboflavin	Niacin	Folate	Iron	Other	Price
365 Everyday Value Cheese Pizza	On ingredients list	On ingredients list	On ingredients list	On ingredients list	1.9mg	2.2mcg Vitamin D, 290mg Calcium, 220mg Potassium	$3.99
Cappello's Cheese Pizza	0mg	0mg	0mg	0mg	6% daily value	10% DV Vitamin A, 10% DV Vitamin C, 20% DV Calcium	$9.99
Udi's Cheese Pizza	0mg	0mg	0mg	0mg	4% Daily Value	6% DV Vitamin A, 15% DV Vitamin C, 40% DV Calcium	$5.45

Table 8: Comparison of the price and nutrient content in gluten-free and gluten containing frozen waffles

Brand	Thiamin	Riboflavin	Niacin	Folate	Iron	Other	Price
365 Everyday Value Homestyle Waffles	On ingredients list	On ingredients list	On ingredients list	On ingredients list	1mg	100mg Potassium	$2.99
Vans Original Gluten Free Waffles	0mg	0mg	0mg	0mcg	1mg	233mg Calcium, 104 mg Potassium	$2.99

Summary of Tables

In most of the products compared in Tables 4, 5, 6, 7, and 8 the gluten free product is not fortified with any of the B-vitamins. All of the gluten-free pastas and cereals were fortified with iron, along with all of the gluten-free breads, except for one. All of the gluten-free breads were also fortified with calcium, but none of the other gluten-free products were. The Arrowhead Mills cereal was fortified with Thiamin, Riboflavin, and Niacin as well, making it the only gluten free product observed that was fortified with various B-vitamins. The manufacturer for the cereal emphasizes their use of ancient grains that are often packed with vitamins and minerals, which are not used by many other companies (Arrowhead Mills, 2020). The buckwheat in the cereal is different than the grains in the other three cereals, thus providing a different vitamin composition.

Frozen and pre-made traditional products often do not have the added B-vitamins on the nutrition label, however, they are on the ingredients lists (Figure 4). Since the amounts are not listed, it is safe to assume that the products meet the standard requirements decided by the FDA. The vitamins are not listed on frozen gluten-free products, because they are not made with the enriched flour used in traditional products.

Gluten-containing products have more nutrients added to them and have lower prices, compared to the gluten-free alternative. Often, the gluten free products that were more expensive did not have any nutritional differences than the cheaper gluten free options. The price of the gluten-free products compared to the traditional ranged from about $1 more to $5 more.

While some manufacturers, like Arrowhead Mills, have decided to use more nutrient dense grains for their gluten-free products, many have not chosen this route. Ensuring that the individual selects a product with many nutrients added when consuming a gluten free diet is imperative to prevent deficiencies.

Figure 4: Gluten containing frozen pizza with enriched flour on ingredients list (Walmart.com)

3 Day Diet Analysis

To further identify the differences in B-vitamins in the diet for an individual consuming gluten and for a gluten-free individual, a 3-day 1800 calorie diet was analyzed using Food Processor software. The caloric intake was based on the typical dietary needs of a 20- year old female. In this case, the individual is 5’8 and weights 165 pounds. The diet was focused on an overall heart-healthy diet developed by the Cleveland Clinic (Cleveland Clinic, 2019). The diet listed below is for an individual consuming gluten. The individual on the gluten-free diet followed the same sample diet, but gluten-free products were substituted when necessary. The

nutrient content of the diet was analyzed using The Food Processor Nutrition Analysis Software 2018 version 11.644 developed by ESHA located in Salem, Oregon.

Day 1:

Breakfast: ½ cup of plain oatmeal (*instant gluten free oatmeal, Quaker)*, 1 cup of 1% milk, ½ banana, ¼ cup of chopped walnuts

Lunch: 2 slices of whole wheat bread (*gluten free bread, Manna*), 2 slices of low-sodium turkey, 1 slice of low-fat swiss cheese, ½ medium tomato, 1 Tbsp of yellow mustard, ¼ cup of shredded lettuce; 6 baby carrots, 6 ounces of fat-free Greek yogurt, and ¾ cup blueberries

Dinner: 6 ounces chicken breast, 1 cup brown rice, 1 cup steamed broccoli, 2 Tbsp. butter

Snack: 1 low-fat string cheese stick and 2 Clementines

Day 2:

Breakfast: 1 egg, 1 whole wheat English muffin (*gluten free English muffin, Ener-g)*, 1 slice low-fat cheddar cheese, 2 ounces of turkey sausage, 1 cup fruit

Lunch: 1 whole wheat tortilla (*gluten free tortilla, Rudi's)*, 4 ounces of light canned tuna in water, 1 Tbsp of light mayonnaise, 2 slices of tomato, ¼ cup of lettuce, 1 cup of low-fat milk, 1 medium apple, 2 cups of spinach, 1 tsp of olive oil, 1 Tbsp balsamic vinegar

Dinner: 6 ounces of salmon, 2 cups of baby spinach, 1 cup blueberries, ¼ cup sliced almonds, ¼ cup feta cheese, 2 Tbsp lite balsamic vinaigrette, ¼ cup croutons (*gluten free croutons, Ener-g)*

Snack: 15 whole wheat crackers (*gluten free cracker, FNDDS)*, 3 Tbsp of hummus

Days 3:

Breakfast: 1 egg, ½ cup spinach, 1 tbsp chopped onion, 1 Tbsp chopped red pepper, 1 slice of toast (*gluten free bread, FNDDS)*, 1 tsp. olive oil, 1 cup 1% milk, and 1 orange

Lunch: 4 ounces of low-sodium ham, 1 slice 1% cheddar cheese, 2 slices of whole wheat bread (*gluten free bread, FNDDS)*, 2tsp. mayonnaise, 3 spinach leaves, 2 slices of tomato, 6 baby carrots, and 1 small pear

Dinner: 2 ounces of whole wheat spaghetti (*gluten free spaghetti, Ronzoni)*, ½ cup marinara sauce, 3 turkey meatballs, ¼ cup Parmesan cheese, 1 cup lettuce, 2 Tbsp. Italian dressing, ½ cup unsweetened applesauce

Snack: 6 ounces light strawberry Greek yogurt, 28 pretzel sticks (*gluten free pretzel sticks, Snyder's of Hanover)*

Gluten Containing Diet:

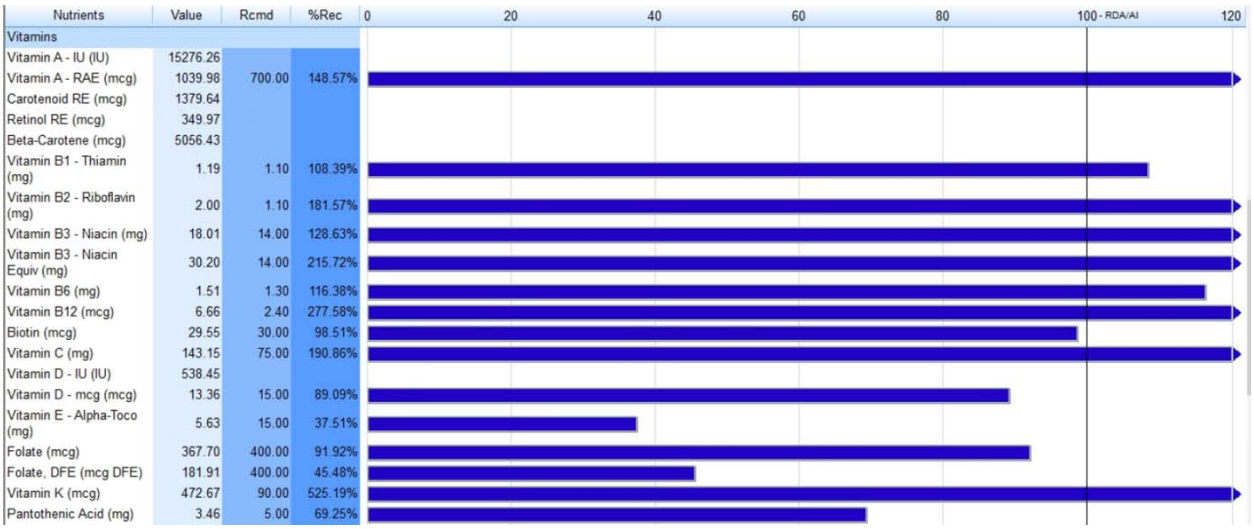
Over the 3-day period, based on the recommended dietary allowance the individual consumed adequate amounts of all B-vitamins, except for folate, which was at 94% adequacy and pantothenic acid. Pantothenic acid would be of concern if this diet continued and could be increased by consuming fortified foods, beef, chicken, organ meats, and vegetables (National Institute of Health, 2020). The other nutrients of concern if this diet was continued would be vitamins D and E, which are also noted as problematic in the US Dietary Guidelines report (Figure 5).

Figure 5: Nutrients in a Gluten Containing Diet

Gluten Free Diet:

During the 3-day 1800 calorie diet for an individual consuming gluten-free products, the recommended dietary allowances were met for all B-vitamins except for biotin and folate. The nutrients of concern if this diet was continued would be biotin, folate, vitamin D, vitamin E, and pantothenic acid (Figure 6).

Figure 6: Nutrients in a Gluten Free Diet



Nutrients	Value	Rcmd	%Rec
Vitamins			
Vitamin A - IU (IU)	15276.26		
Vitamin A - RAE (mcg)	1039.98	700.00	148.57%
Carotenoid RE (mcg)	1379.64		
Retinol RE (mcg)	349.97		
Beta-Carotene (mcg)	5056.43		
Vitamin B1 - Thiamin (mg)	1.19	1.10	108.39%
Vitamin B2 - Riboflavin (mg)	2.00	1.10	181.57%
Vitamin B3 - Niacin (mg)	18.01	14.00	128.63%
Vitamin B3 - Niacin Equiv (mg)	30.20	14.00	215.72%
Vitamin B6 (mg)	1.51	1.30	116.38%
Vitamin B12 (mcg)	6.66	2.40	277.58%
Biotin (mcg)	29.55	30.00	98.51%
Vitamin C (mg)	143.15	75.00	190.86%
Vitamin D - IU (IU)	538.45		
Vitamin D - mcg (mcg)	13.36	15.00	89.09%
Vitamin E - Alpha-Toco (mg)	5.63	15.00	37.51%
Folate (mcg)	367.70	400.00	91.92%
Folate, DFE (mcg DFE)	181.91	400.00	45.48%
Vitamin K (mcg)	472.67	90.00	525.19%
Pantothenic Acid (mg)	3.46	5.00	69.25%

Conclusion:

In both diets, folate is the most limiting vitamin, which poses risks for anemia, birth defects in the brain, and the spinal cord of a developing fetus if the mother is suffering from deficiency (Cafasso, 2019). It is recommended that women of child-bearing age take folic acid supplements due to its effect on fetal growth. To prevent folate deficiency, consuming foods such as leafy green vegetables, citrus fruits, and fortified cereal can be beneficial.

Overall, most of the recommended dietary intakes were met for the B-vitamins in both diets. The gluten containing diet with enriched grains did allow for the individual to consume more B-vitamins than the gluten free diet. If an individual is not consuming adequate amount of these nutrients, it can result in health consequences from deficiency. Too much of these vitamins over a period of time can result in toxicity, which has its own health concerns. The conclusion to this analysis is that the gluten containing products have less vitamins enriched in them resulting in an increased risk for deficiency.

A Dietitian's Review

From a dietitian's standpoint, the only recommended treatment for celiac disease or gluten allergies is a gluten-free diet (Cooper, 2012). The key to prevent deficiencies is to also promote gastrointestinal healing by consuming a nutrient-dense diet, which focuses on fruits and vegetables, lean protein, and gluten-free whole grains. This type of diet will allow for an individual to get the necessary nutrients that most patients would need. Even following a diet like this, gluten-free grains do not have the same fortification standards as traditional products, so even a healthy gluten-free diet may result in deficiency. Dietitians can help with this by recommending fortified gluten-free products and necessary supplements to correct these nutrient deficiencies.

One situation dietitians often run into is calcium and vitamin D deficiencies in individuals with celiac disease, which can result in osteopenia or osteoporosis (Cooper, 2012). While most milk and dairy products are high in these vitamins and gluten free, lactose intolerance may be a secondary celiac disease symptom. Lactose-free, soy-based, and fermented dairy products are recommended for adequate calcium consumption in replacement of dairy products. Calcium may also be found in leafy green vegetables, naturally gluten-free grains, fortified orange juice, and beans. Vitamin D has limited food sources, but can be found in fish, nuts, avocado, enriched eggs, and plant oils. Enriched eggs are highly recommended, because they also contain omega-3 fatty acids, which have been shown to decrease intestinal inflammation in celiac disease patients. If these recommendations are still not enough, supplementation is the next step.

In the end, gluten is not bad for you if you do not have celiac disease (Bucklin, 2018). In fact, gluten-free products are often higher in calories, fat, and sugar, while lacking essential vitamins and minerals. Gluten containing foods such as bulger and barley are some of the

healthiest foods that can be eaten, because they are so full of vitamins and minerals. If not planned correctly, going gluten-free without it being a health necessity can lead to nutritional deficiencies. Going gluten-free can also skew the results of blood tests when testing for celiac disease. If you are considering going gluten free, visit with a doctor first.

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