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I. Introduction

In today's market, foods containing artificial food dyes are extremely popular. Consumers have been purchasing products with added food dyes at an increasing rate because of how appealing it looks. They have become increasingly normalized as an additive in foods every year. They are extremely hard to avoid since they are found in tons of food items including juices, jellies, jams, condiments, puddings, candy, chewing gum, dairy baked goods and lots more. Because of the large demand for foods with artificial food dyes, companies are generating large amounts of profit from these products. Artificial food dyes are extremely common and used in tons of everyday products which is why they are so hard to avoid when buying food. Although artificial food dyes generate lots of money each year and benefit the economy, many researchers have conducted studies concluding that artificial food dyes have harmful effects on people's health. Although the research conducted proved that artificial food dyes lead to various health concerns, the US does not implement strict rules or regulations when making decisions to allow the dyes to be used in our food products, however in the European Union their rules and regulations are a lot more strict when it comes to the allowance of artificial food dyes in their food products. Despite the negative effects that artificial food coloring has on our health, artificial food colorings are still legal for consumption, and are not strictly regulated in the US, because of the large amount of money they generate.

II. Health Effects of Artificial Food Dyes

It is crucial to understand the role that nutrients play in human development. The foods that people choose to eat can directly change their genetic structure and the expression of genetic factors that play a crucial role in brain development. The human body requires proper nourishment and nutrients because without them, people can develop fatal diseases. Lack of vitamins and minerals as well as eating harmful chemicals can cause chronic health issues and negative behaviors (Gultekin). In a study conducted by Faith Gultekin, it was proven that malnutrition and over abundance of chemicals can have adverse effects on the Central Nervous System (CNS). Since most food dyes are deemed unsafe and harmful for human consumption by health professionals, the consumption of these artificial food dyes can lead to many health risks (Gultekin).

Artificial food dyes are found in so many foods, they are almost impossible to avoid. Not only are they extremely popular they are also extremely detrimental to people's health. Studies have confirmed that artificial and synthetic food dyes are a major source of food intoxication and cause severe health issues such as attention deficit hyperactivity disorder (ADHD). A study showed that 73% of children who have ADHD showed fewer symptoms of ADHD when artificial food dyes were removed from their diet. It was concluded that food dyes increased the hyperactivity of children in the age range of three to nine. Along with hyperactivity, food dyes, specifically Yellow 5, was shown to cause many other behavioral changes as well including irritability, restlessness, depression, and trouble sleeping (Dey).

In 1973, the idea that artificial food dyes were harmful was only a hypothesis. A pediatric allergist, Benjamin Feingold, proposed this hypothesis and concluded that children who were considered hyperactive, or hyperkinetic suffered from sensitivities to specific elements that were

found in their diets, mainly artificial flavors and colors. Feingold had placed many children that were considered “hyperactive” on a diet that eliminated any artificial food dyes and their behavioral problems diminished (Connor).

This study not only drew large amounts of attention from the public, but was also the beginning of the vast amount of research conducted on artificial food dyes. In another study, conducted in 2012, Keith Conners, one of the early leading researchers on these ingredients conducted a study that placed 13 children, 8 of whom were diagnosed with ADHD, on a “modified Feingold diet” in which all artificial food dyes were removed. After multiple weeks, these children had a 41-percent reduction in their behavioral issues. This study was further conducted and implemented a second part. In this double-blind study, the same children were instructed to eat two cookies everyday for one week. Some childrens’ cookies contained artificial food dyes and others did not. Each child’s parents rated their behavioral issues for a three hour period after having dinner. Those who had the cookies containing the artificial food dyes displayed significantly more behavioral issues and 31% of them exhibited marked reactions. Their reactions were described as those of a “spoiled brat”. They were “annoying, intrusive, unpredictable, and persistent.” This data confirmed that artificial food dyes are disruptive to the development of young children and needed to be further examined on the way they affect the central nervous system (Connor).

Further research in this study conducted by Connor suggested that there was serious damage to the brain’s inhibitory or braking ability of many children. Their intellectual performance was uneven and there were deficits in certain parts of their brains. Many children had trouble with simple tasks including copying designs or determining the difference between words that sound alike. Their activity levels were higher than usual and they were “restless,

impulsive, and inattentive." These symptoms were similar to those of certain clinical conditions that arose from brain damage (Connor).

In another study conducted by Boris and Mandel in 2013, it was determined that there was significant regression in the symptoms of children with ADHD when implementing the "Feingold diet" which was a diet free of artificial food dyes. The children in this study that were previously diagnosed with ADHD were reported to have been responding better when removing the artificial food dyes from their diet. There was a significant decrease in hyperactive behaviors when these artificial food dyes were no longer being consumed (Gultekin).

Along with behavioral issues and ADHD, results of several studies indicated that artificial food dyes contain contaminants that are known to lead to other health concerns various types of cancers and tumors and others. Many artificial food dyes, specifically Red 40, Yellow 5, and Yellow 6 contain benzedrine, 4-aminobiphenyl and 4-aminoazobenzene which are potential carcinogens. These contaminants are legally allowed to be used in these food dyes because they present "low levels" that are deemed safe by the government but are still considered harmful by health professionals (Dey).

Most artificial food dyes that are approved by the FDA raise health concerns by many health professionals. This includes Blue 1, Blue 2, Citrus Red 2, Green 3, Orange B, Red 3, Red 40, and Yellow 5. A study conducted in 2010, suggested that there was a correlation between Blue 1 and kidney tumors, and also raised questions about the potential harmful effects on nerve cells. Also, Blue 1 was shown to inhibit neurite growth and cause neurotoxicity which alters the nervous system. This raises concerns particularly for babies whose blood-brain barriers are not fully developed. Similar to Blue 1, the statistics in studies conducted involving Blue 2 shown to lead to tumors, and brain gliomas (Kobylewski).

Citrus Red 2 was found to be toxic to rodents. (Research has shown that humans and rodents have brains that are remarkably similar in structure and function). They caused tumors in the bladder and other organs. The FAO/WHO Expert Committee on Food Additives has stated that “This color should not be used as a food additive.” Similarly, Green 3 was also shown to cause tumors specifically in the bladder and testes in high-dose male rats (Kobylewski).

In a study testing the toxicity of Orange B, it was concluded that male and female rats had lymphoid atrophy of the spleen, bile-duct proliferation, and had chronic nephritis (Kobylewski).

Red 3 was found to be a secondary carcinogen and in 1990 was terminated for use in cosmetics, externally applied drugs however it is still permitted to be ingested in drugs and foods. There is a high level of concern for the prevalent use of Red 3 because it is an acknowledged carcinogen. Along with Red 3, Red 40 is equally as harmful. Data suggests that Red 40 increased the appearance of tumors in mice and hypersensitivity reactions (Kobylewski).

Yellow 5 has been shown to pose many health risks as well. Six out of the eleven mutagenicity studies conducted by Kobylewski have indicated potential issues. Similarly, Yellow 6 posed many issues as well since it is filled with many cancer-causing chemicals. Rodents that were given a high dosage of Yellow 6 experienced many incidents of adrenal medullary adenomas which are tumors that form in the adrenal glands. (Kobylewski).

Along with various types of cancers, tumors and health issues, artificial food dyes are shown to cause allergic reactions including hives, and asthma symptoms. The 3 most likely artificial food dyes to cause an allergic reaction are Red 40, Yellow 5, and Yellow 6. They are ironically the three most frequently consumed food dyes on that market. In a study that used participants who have chronic hives and swelling, it was found that 52% of the participants had

an allergic reaction to artificial food dyes (Dey). Tartrazine, also known as Yellow 5, has been tested to see if it causes exacerbations of asthma and cross-sensitivity to aspirin. A study concluded that conditions such as hay fever, allergic rhinitis, and eczema were some of the many allergy symptoms the participants faced (Arden).

Food dyes have been a public concern for years. In 1984 Mark Novitch, the FDA's Acting Commissioner stated that Red 3 was "of the greatest public health concern… the agency should not knowingly allowed continued exposure of the public to a provisionally listed color additive that has clearly been shown to induce cancer while questions of mechanism are explored" (Kobylewski).

III. Economic & Social Effects of Artificial Food Dyes in the United States

Many health professionals, the government, and private agencies acknowledge the detrimental effects of artificial food dyes yet they are still legal in the US. Not only are they legal, but also extremely popular and used in products that use the tools of marketing to interest consumers. Color has been a key component in increasing the ultimate appetizing value and consumer acceptance of many different foods and beverages. The use of synthetic food colors has increased drastically when compared to the use of natural food colors used by food manufacturers. Their low cost, improved appearance, higher color intensity are what interest consumers the most (Dey).

In one study conducted by Singh Vijeta in 2015, it was found that the color of a food item plays a large role in influencing a consumer preference. Foods with bright, vibrant colors were seen as more appealing to many. This study took place in a busy and fast moving metropolitan city with a large amount, and a wide variety of consumers. A group of 80 respondents located in

this city were surveyed and asked questions about the food they purchased. It was found that the color and flavors of these foods were a compelling factor in their choice to buy the product (Vijeta).

In a study conducted by Batada in 2015, it was found that a large amount of foods containing artificial food dyes were used in products that were marketed towards children. This study assessed the percentage of products in grocery stores marketed towards children that have artificial food dyes in them. Information from 810 different products were collected. It was found that 43.2% (over 350 of those products) contained artificial food dyes. In total, 96.3 percent of the candies that were tested contained artificial food dyes, 94% of fruit flavored snacks, 89.7% of and powdered drink mixers all used artificial food dyes. Out of all 66 companies that were tested in this study, it was found that 41 of them marketed their products which contain artificial food dyes. These artificial food dyes appeared very attractive to children and they were more likely to want to try these products (Batada).

Because of the large demand for products with a bright and vibrant color, the use of these harmful dyes remain legal for consumption in America. Starting in the 1870's food companies began using artificial food dyes as a marketing tactic. Not only were the colors appealing but these artificial food dyes were cheaper, more stable, and more vibrant than most natural coloring options. The emergence of this demand for products with artificial food dyes came about during the same time the growth of mass production and mass marketing began in the American food industry. Artificial food dyes gave food manufacturers an economical way to standardize their products and help establish brand identity through their colorful appearance. Color was an easy factor for manufacturers to control, reproduce and commoditize. Companies would use these

artificial food dyes as a way to signal consistent quality that visually appealed to the consumers of their products (Hisano).

As artificial food dyes were on the rise, a national mass distribution of artificial food dyes with low prices, and low margins became a competitive advantages between competing companies. By the late 1970s, the United States became the leading user of artificial food dyes across the globe. Products with artificial food dyes were being consumed in larger amounts than any other country; 2300 tons of artificial food dyes in one year (1977), compared to the entire Western European area where only 1,050 tons of artificial food dyes were consumed that year. By the year 2015, the global market for artificial food dyes had grown to about $1.5 billion (Hisano). In 2019, foods with artificial food coloring generated $2.1 billion and is estimated to reach $3.5 billion by 2027 (Dey).

For lots of companies, the use of artificial food dyes was critical to enticing customers and generating sales. For example , by the year 1895, over 80% of artificial food dyes used to color margarine were artificial. Also, the Jell-O company was no longer using color from vegetables but was using artificial food dyes . Along with these manufacturers, the dairy industry was one of the most successful in recognizing the economic benefits of implementing artificial food dyes into their products. Manufacturers of butter began using artificial food dyes to color their products. Companies such as Wells, and Richardson & Company began using artificial food dyes Yellow AB and Yellow OB to color their butters, cheeses and margarine. The transition from using food coloring from vegetables to artificial food dyes significantly decreased the cost to make their products because using artificial food dyes was significantly cheaper than going through the process of extracting the color from vegetables. In 1907, the cost of using food dyes that came from vegetables cost about $2.00 per gallon (about $50.00 in 2015 US dollars),

compared to the cost of using artificial food dyes which only cost between $1.60 to $1.70 per gallon (about $40.00 to $45.00 in 2015 US dollars). Along with a decrease in costs, manufacturers were able to achieve a uniform color in which all of their products would be. This consistency was very appealing to their customers and was one of their main marketing points. Companies who created these artificial food colors that were specifically used in butter stressed the idea that with only a few cents invested in their products will lead to dollars in the pockets of dairy farmers. They stressed the economic benefit of using the artificial food dyes, stating that they were essential in determining the value of their butter.

Along with the dairy industry, the confectionary industry also boomed after their implementations of artificial food dyes. Many confectioners began using these artificial food dyes because of how economical they are. Once they realized they only needed to use a "few grains" to dye hundreds of pounds of candy, these products became more accessible and cheaper to make. Candy became inexpensive and readily available because of the mechanization of candy and the decrease in price. By adopting artificial food dyes, confectioners were able to maximize profits (Hisano). Ultimately, there are many specific food industries that significantly benefit from using artificial food dyes in their products

IV. Comparison of Regulations of Artificial Food Dyes in the European Union vs The United States

Compared to the European Union, the US has made significantly less changes in regards to allowing certain food dyes to be consumed and used daily and is more lenient with the amount of artificial food dyes that are allowed to be consumed. For example, in the US, a colored food ingredient that contributes to its own color when mixed with other foods such as chocolate in

chocolate milk, or cherry in cherry yogurt are not considered color additives. In the European Union, there are three artificial food dyes namely Orange B, Citrus Red No. 2, and FD&C Green No.3 that have been banned. However, these dyes are still permitted to be consumed in the United States. The process for a new food additive to be authorized in the European Union is a more lengthy process than it is in the United States. Not only is it more lengthy, but in the European Union the applicants need to justify the reason as to why they believe the new additive is needed and why it should be allowed. They must also be able to prove that the additive is not misleading to consumers in any way. In the United States, these requirements do not exist and the approval of a new additive can be authorized after a safety assessment (Lehto).

Also, in the European Union, they use many studies to determine if the additive is toxic and to what level of toxicity it is. In the United States, they use a classification system which determines the level of concern the additive has and if it has a low level of concern, then the minimum amount of testing is conducted. The European Union sets limits for the maximum amount of heavy metals contaminants, including arsenic, lead, cadmium, and mercury, that are allowed to be put into artificial food dyes. However, the US does not regulate the content of heavy metal additives allowed in artificial food dyes (Lehto).

In the European Union, the artificial food dyes that are used in each product must be clearly stated in the ingredients list of every product stating its full name. They also implemented a precautionary principle in regards to foods containing tartrazine, also known as Yellow 5. Since many consumers were concerned about the harmful effects of tartrazine on children, the European Union required that in any product that contained this dye that there was a warning label stating the potential harmful effects on the activity and attention in children. Contrastingly, in the United States, artificial food dyes are allowed to be listed on an ingredients

list with just its simple name or could be labeled as “artificial color” or an equally informative term. There are also certain foods that are exempt from stating they contain artificial food dyes at all. This includes any dye added to butter, cheese, icecream, etc (Lehto).

As more research becomes public, consumers have become more aware and upset by the dangers of artificial food dyes. These concerns have been putting an immense amount of pressure on the food industry. Many companies recognize consumers’ concerns and are attempting to steer away from artificial food dyes. They are replacing them with natural, sustainable, and healthier options in order to reassure consumers that the products they are eating are safe and won’t cause health issues. Because of the growing concern of artificial food dyes, proper regulatory practices and guidelines are still in the process of being developed and are constantly being improved upon. For example, The FDA established an Acceptable Daily Intake (ADI) for the maximum amount of artificial food dye that should be consumed in one day (Martins).

Despite their attempt to begin implementing regulatory practices, there has not been much progress in getting rid of artificial food dyes and harmful chemicals in food in the United States. Most information about artificial food dyes and other harmful chemicals in food are incomplete and in some cases ambiguous. Also, most of the food label information regarding these artificial ingredients require the addition of a warning or safety message. Overall, the US should implement more strict rules and regulations when making decisions to allow artificial food dyes in food products (Martins) .

V. Potential Future Solution

Through studies conducted by Natalia Martin in 2016, it was found that nature is highly rich in color pigments and the majority of these colorful plants have not been exploited yet for their coloring abilities. Many naturally colorful plants in nature have not been tested on at all or enough to use because their coloring abilities can be easily ruined by external factors including pH, temperature, light, oxygen, solvents, presence of enzymes, proteins, metallic ions and their structure and concentration used. There are currently studies that are being conducted to provide new information and procedures to extract the color from nature in order to replace artificial food dyes. These new sources of food coloring need to continue to be assessed to test their coloring abilities and the current natural food sources that have already been discovered should continue to be used and replace harmful artificial food dyes (Martin).

VI. Conclusion

Artificial food dyes have been proven to cause many health issues such as cancers, tumors, allergies and also promote ADHD in children. Many studies have proven that artificial food dyes are detrimental to our health and should no longer be used in foods. Despite their harmful effects, artificial food dyes contribute significantly to the success of the economy. Products using artificial food dyes generate large amounts of profit each year and continue to become more popular. These economic benefits cause corporations such as the FDA to be hesitant in completely banning artificial food dyes and taking them out of the market. Ultimately, artificial food dyes are harmful for our health but beneficial for the economy. It is difficult to reach a unanimous consensus of whether to continue to allow food dyes in the market and to completely get rid of them.

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