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Consumption of gluten free products increases heavy metal intake

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A B S T R A C T

Background: Despite the fact that the prevalence of celiac disease (CD), an autoimmune bowel disease triggered by gluten, has almost been constant at 1%, already one in four US-American citizens claim to avoid gluten from their diet. The popularity of gluten-free products has risen worldwide and manufacturers report record turnovers. Besides CD, mostly non-medical reasons underlie the recent boom of the gluten-free diet (GFD). Celebrities and bestseller authors reach millions of followers with the hypothesis that gluten is responsible for overweight, reduced performance or other adverse health effects.
Results: Recent studies find higher concentrations of heavy metals in blood and urine, especially arsenic and mercury, among people following a GFD compared to people not following a GFD. Other recent studies show an association between GFD and the risk of cardiovascular diseases and type 2 diabetes.
Conclusion: The elevated concentrations of heavy metals can so far not be attributed to diet shifts in a GFD. However, due to the natural growth in flooded paddies, rice readily absorbs arsenic and mercury and can accumulate the toxins in the bran. As gluten-free products often contain a large share of rice flour, this connection should be subject to further studies. The lower amount of dietary fiber consumed when grains are withdrawn from the diet could explain the higher risk of cardiovascular disease.

1. Introduction

Patients with celiac disease (CD) must live on a gluten-free diet (GFD) life-long because gluten causes intestinal inflammation in these subjects [1]. However, more and more people voluntarily withdraw gluten from their diets. While a GFD is vital for people suffering from CD, it is in vogue for others. Many people heard of potential harm that gluten causes to human health and turn to gluten-free products because they want to avoid suspected risks of gluten. To date, the only indication for a permanent and strict GFD is CD. Once gluten is withdrawn, their symptoms, secondary diseases such as malabsorption and quality of life improve [1, 2]. The worldwide prevalence is about 1%, although big regional differences are observed [2–5]. Related disorders like wheat allergy and non-celiac gluten sensitivity (NCGS) request a diet poor in gluten for some individuals, though not to the same extent as a CD does [6]. Recently published studies suggest that a GFD can be responsible for elevated heavy metal concentrations in blood and urine. Replacement of gluten through gluten free products containing rice flour could be the cause of this phenomenon. Analysis of heavy metals in rice showed higher concentrations, especially of arsenic and lead, compared to gluten containing grains [7]. Furthermore, an association between a GFD and increased incidence of coronary heart disease was shown [8]. The following short review is an approach to understand the impact of these results.

1.1. The boom of gluten-free diets

Although the number of diagnosed CD has almost been constant at 1%, one in four US-American citizens follows a GFD, which corresponds to a 67% increase since 2013 [9].As seen in a study by Lis et al., who found that 41% of non-celiac athletes follow a GFD at least 50% of the time, reasons behind the current trend are often of non-medical origin [10]. According to a survey of 1500 US-American adults buying gluten-free products, 35% did so for “no reason”, followed by the opinion that they are a “healthier option” and for “digestive health” [11]. While only a decade ago, celiac patients were often misunderstood and excluded from social life, a fad towards a GFD has been observed in recent years. The Nielsen Company questioned 30,000 individuals from all over the world on their body image and health. 21% of participants rated gluten-free as “very important” in food purchase decisions. Young people formed the group most attracted to gluten-free products and are willing to pay a price, which is on average more than twice as high [12, 13].

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With the increasing evidence of the effectiveness of GFD in patients of NCGS, many believe a GFD can be effective for the general population [14, 15].

Moreover, gluten is nowadays perceived as toxic and harmful to healthy individuals and promoted by bestseller authors, athletes and celebrities [10, 16–20]. When gluten-free products could in the past only be found in health food stores and online shops due to the moderate demand of only a small number of celiac patients, nowadays a wide variety of gluten-free products is found in common supermarkets, heeding the increased demand [21]. The gluten-free market is fast-growing: Revenue of products in Germany was 39 Million Euro in 2010, 54.2 Million Euro in 2012 and reached 105 Million Euro in 2015, which corresponds to a 93.7% increase in just three years [22, 23]. The global market for gluten-free products reported a revenue of 4.63 Billion US-Dollars in 2015 with North America having the biggest market share [24].

1.2. Critical nutrition-related aspects of a gluten-free diet

Recent studies show that there are certain risks coming along with a GFD. The reason can probably be found in the high content of rice and rice-based products substituting the grains in gluten-free products. Rice is known to accumulate the toxic substances arsenic, mercury, cadmium and lead, all of which are among the “ten chemicals of major public health concern” stated by the WHO [25]. The concentration is highest in the bran, which is removed to receive white from brown rice during milling. Brown rice does thus contain higher amounts of heavy metals than polished (white) rice [26]. These heavy metals have been found in blood and urine samples of people following a GFD, partly in significantly higher amounts than in samples of people not following a GFD [27]. Raehsler et al. analyzed the blood and urine samples of 32 people on a GFD, using the national representative data of NHANES from 2009 to 2012. They compared the outcome with data of 3901 individuals not on a GFD. Total blood mercury was as high as 1.37 µg/L in subjects on a GFD compared to 0.93 µg/L in subjects not on a GFD, which accounts for an increase of 47%. The mean total urinary arsenic in subjects on a GFD equaled 15.15 µg/L and was thus 80% higher than in subjects not on a GFD, having a mean of 8.38 µg/L. Cadmium and lead concentrations in blood were 25% (0.42 vs 0.34 µg/L) and 23% (1.42 vs 1.13 µg/L) higher in subjects on a GFD, respectively. After celiac patients had been excluded, the significance in higher blood and urine heavy metal concentrations remained [27]. This suggests an association between gluten withdrawal and higher measured heavy metal concentrations rather than a causal relationship between CD and higher heavy metal concentrations.

One recent study by Bulka and her team raised concern about the GFD worldwide. Data from NHANES collected between 2009 and 2014 was obtained. Blood and urine heavy metal concentrations of people who were on a GFD (self-reported, $n = 73$) were compared to people who were not on a GFD ($n = 7398$). There was an 8% and 12% increased urine concentration of lead and cadmium, respectively. The total amount of mercury in blood was > 60% higher in people who reported to be on a GFD (1.3 µg/L) compared to those not on a GFD (0.8 µg/L). Furthermore, the total urinary arsenic concentration was significantly higher in the group following a GFD, with 55% higher concentrations (12.1 µg/L vs. 7.8 µg/L) [28]. Table 1 shows the heavy metal concentration measured in the above mentioned studies.

1.3. Arsenic

Inorganic arsenic is a major health problem in many countries with high arsenic concentrations in groundwater, affecting > 100 Million people who consequently suffer from various forms of cancer, skin lesions and neurological effects [29–32]. The impacts are especially dramatic during pregnancy and early childhood. Arsenic can cross and accumulate in the placenta and induce negative pregnancy outcomes [32, 33]. Infants and children form the subpopulation most vulnerable to the toxic effects of even low doses of arsenic [34, 35].

Arsenic content in drinking water has been regulated by the WHO since 1958 (0.01 mg/L) and recently also in rice (0.1 mg/kg – 0.3 mg/kg) [36, 37]. Reference value for arsenic in urine is set at 15 µg/L but may be more than twice as high for people who consumed fish 48 h prior to testing. This value is based on 95th percentile urinary arsenic concentrations in adults from representative data from 1998 [38]. The urinary arsenic concentrations of people adhering to a GFD compared to people not following a GFD (15.15 µg/L vs. 8.38 µg/L in the study of Raehsler and 12.1 µg/L vs. 7.8 µg/L in the study of Bulka) are partly exceeding the reference value and are therefore of concern [27, 28].

Rice and rice-based products have been reported with elevated inorganic arsenic concentrations in many studies, in parts exceeding the regulations set by the European Commission [39, 40]. High variations in origin and type of rice have been shown [40–44]. Infants and children are more susceptible for the adverse effects of arsenic and yet consume two to three times more inorganic arsenic from food in relation to their body weight than adults [32]. This is why it is not recommended to feed infants exclusively rice and rice-based products, especially if they are not affected by intolerances. Wheat, maize and oats are aerobically grown and do not translocate arsenic from soil or water to the grain like seen in rice, and show lower arsenic concentrations [45]. There are rice-containing but arsenic-free products available. Methods known to minimize the arsenic content in processed food are preferable to provide the consumer with safe products [43, 46].

Several studies tested gluten-free products on their arsenic content. Rice- free, mainly maize-based gluten-free food samples were nearly free of arsenic, whereas rice-containing food samples like bread and pasta showed the highest arsenic concentrations with a clear domination of inorganic arsenic. But researchers could also prove that rice-containing gluten-free products can be free of arsenic, which suggests that low-arsenic rice is available and a favorable ingredient for rice-based gluten-free products [46]. Similar outcomes were reported in a study measuring arsenic content in gluten-free infant foods, where rice-free samples were arsenic-free and the rice-containing products reached very high arsenic concentrations [47–49].

Although there are good substitutes for gluten-containing carbohydrates, the most common replacements for wheat is rice flour [50]. With the increased popularity of GFD, the higher availability and large selection of gluten-free products, the arsenic problem affects more and more people following a GFD. Cookies, cakes, bread, and cereals contain rice flour, flakes, and syrup in amounts often unknown.

1.4. Mercury

Mercury occurs ubiquitously in the environment and is considered as a pollutant and thus is highly toxic to humans. The exposure of mercury is mainly through seafood (methylmercury), dental amalgam fillings, vaccines, or work-related. Once absorbed in the body, methylmercury accumulates in the brain and can cross the placenta and the blood-brain barrier [51]. It represents an organic and one of the most toxic forms of mercury. Mercury is neurotoxic and potentially involved in the development of neurodegenerative diseases like amyotrophic lateral sclerosis (ALS) [52]. Exposure to mercury is further linked to blindness, birth defects, and mental development impairments [51].

Unborn children represent the most vulnerable group to methylmercury exposition. Pregnant women with a high intake of methylmercury can harm their fetuses without developing own symptoms [51]. Exposure to methylmercury in the womb constitutes a risk of severe neurodevelopmental damages of the fetus, resulting in impaired language, memory, fine motor and cognitive skills [53, 54]. As part of an omega-3-rich diet and for better iodine status, it is recommended for pregnant women to consume fish two times a week, but predatory fish