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INTRODUCTION

Introduction to the Special Issue on the Nutritional Value of Potato

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This issue was organized following discussions among potato scientists about the need to acknowledge the positive attributes of potato to human health, with a focus on recent research advances. In this special issue of the American Journal of Potato Research, we have assembled experts to share their expertise on potato and human nutrition from diverse perspectives, from its contribution as a source of energy and micronutrients to its value in preventative medicine. We hope this collection of articles will be accessible to a broad range of readers not only within the potato community, but also in other disciplines.

For hundreds of years, the potato has been a major source of nutrition for human populations. In the thirteen century, the Inca Empire was built with the potato as a primary source of sustenance (Brush et al. 1981; de Jong 2016; Beals 2019). Similarly, the Industrial Revolution in nineteenth century Europe was fueled in large part by the introduction of the potato from the New World (Nunn and Qian 2011; de Jong 2016). Potato was a significant food crop because it sustained small farmers. One acre of land and a milk cow provided all the nutrition needed for a family of eight (Nunn and Qian 2011). Today, the potato is the most important vegetable crop worldwide, and follows only wheat and rice as a food crop.

The United Nations General Assembly declared 2008 as the "Year of the Potato" to highlight its importance as a world food crop. The Director General of the FAO at that time, Jacques Diouf, declared that "The potato is on the frontline in the fight against world hunger and poverty." Because of its broad adaptability and high nutritional value, the potato has been widely adopted in countries with food security challenges. The Commentary by Wang and Wang (2019) describes the Chinese government's strategy to address domestic food security by increasing potato production. In fact, today, more potatoes are produced in developing countries than in developed ones. In the past 50 years, potato consumption has increased by 70% in both Africa and Asia (Wijesinha-Bettoni and Mouille 2019). Potato is an important crop in the developing world because it produces high yields on small parcels of land, and it can be sold as a cash crop to sustain the livelihoods of small farmers (Wijesinha-Bettoni and Mouille 2019; Wang and Wang 2019).

In contrast, potato consumption has been declining in Europe and North America. In the U.S., potato consumption increased steadily during the latter part of the twentieth century, but then experienced a sharp decline that has only recently begun to level off (Fig. 1). The downturn corresponds to the increasing popularity of low carb fad diets broadly promoted in the media. Potato is considered to be a starchy vegetable, leading to a focus on its contribution as a source of carbohydrates (Beals 2019). However, as a vegetable, potato is also an excellent source of dietary fiber, vitamin C, vitamin B6, potassium, magnesium, iron, carotenoids and phenolic acids (Beals 2019; Navarre et al., 2019). It is becoming recognized as a functional food not only for the general consumer but also for athletes, who demand nutrient-dense, high quality carbohydrates (Kanter and Elkin 2019).

Potato is the world's most popular vegetable because most people find its taste appealing, it is a satisfying comfort food, and it is inexpensive and readily available year-round. As a food, it is consumed mainly as carbohydrate source. However, there is much to learn about potato starch and human health. For example, little is known about variation in starch quality among cultivars and across production environments. Raw potato starch is nearly indigestible, but cooked potato starch is more easily digested, resulting in a higher glycemic index. The development of potato varieties with altered starch properties, such as a higher amylose/amylopectin ratio and longer amylopectin chain lengths may decrease glycemic index (Dupuis and Liu 2019). Potato starch is used extensively in the food industry, where processing technologies offer opportunities to alter the digestion rate and lead to healthier foods, ranging from fat-free meats to gluten-free products (Dupuis

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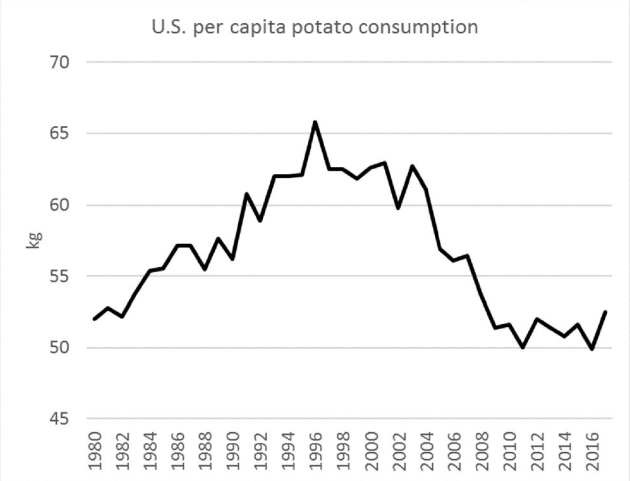

Fig. 1 Per capita consumption of potatoes in the U.S. since 1980. USDA-ERS

and Liu 2019). Resistant starches in potato contribute to intestinal health by promoting the growth of beneficial microbes in the gut (Bibi et al. 2019).

Studies of potato chemistry are important in order to understand this vegetable's potential contributions to human nutrition. However, it is both important and challenging to elucidate the interactions between potatoes and the people who consume them. This is a high priority in light of the stature of potato as a major food source. The health benefits of potato are influenced by cultivar, cooking method, storage conditions, and other foods consumed (Jayanty et al. 2019; Navarre et al., 2019; Taylor 2019). In the high Andes, where thousands of land races are grown and potato consumption is high, varietal differences in nutritional value can impact human health (de Haan et al. 2019). Cultural preferences influence cooking methods, which can also impact human health. For example, water soluble vitamins (B and C) and potassium are leached out of potatoes when they are boiled (Bethke and Jansky 2008; Wijesinha-Bettoni and Mouille 2019).

Because potatoes are eaten in large quantity by much of the population, they are uniquely positioned to impact health. Anti-inflammatory compounds in potato, including resistant starch, fiber and anthocyanins, can contribute to gut health and reduce chronic diseases, such as inflammatory bowel disease (Bibi et al. 2019; Reddivari et al. 2019). Fermentable resistant starch can also improve colon health and reduce the incidence of colon cancer (Vanamala 2019). In addition, polyphenolic compounds in potatoes have been shown to reduce the proliferation of colon cancer stem cells.

Anti-nutrients in potato include glycoalkaloids and acrylamides (Wijesinha-Bettoni and Mouille 2019). Glycoalkaloids can be toxic if consumed in high quantities, although dozens of recent studies show potential health-promoting effects of glycoalkaloids, especially anti-cancer activity in animal and cell studies. Levels vary by cultivar, production environment, and storage environment (Valkonen et al. 1996; Friedman 2006). Breeders monitor glycoalkaloids and do not release high glycoalkaloid cultivars. Acrylamides are produced during high temperature cooking of carbohydrate-rich foods, including potato chips and fries. They act as neurotoxins and are believed to be carcinogenic. In recent years, targeted efforts by breeders and the processing industry have been effective in reducing acrylamide levels in processed potatoes (Bethke 2013).

As science strengthens the connection between diet and health, and the media report that connection, consumer interest in the nutritional value of foods is increasing (Navarre et al., 2019). Despite negative press, potato is versatile, economical, nutrient dense and part of the mainstream American diet (Beals 2019; Navarre 2019; Bamberg and Greenway 2019). New studies are providing insights into the potential for potato to manage weight and hypertension (Beals 2019). Extensive and accessible genetic resources offer breeders opportunities to add to the nutritional value of potato (de Haan et al. 2019; Navarre et al., 2019). Breeders have not typically focused on nutrition and flavor. These are complex traits and it is especially difficult to make breeding progress in an asexually propagated tetraploid crop. However, studies worldwide are now evaluating the potential to breed new potato varieties using inbred diploid parents (Lindhout et al. 2011; Jansky et al. 2016; Ye et al. 2018). This new breeding system would allow traits to be added incrementally to existing varieties, through strategies such as backcross breeding and the creation of recombinant inbred lines. Consequently, nutritional and flavor components can be added to inbred line parents if genetic markers are available to track and select them. Another potential benefit is that diploid landrace cultivars could be used directly in breeding programs. This germplasm is recognized for its exceptional flavor, high nutritional value, and other consumer-oriented traits such as bright skin and flesh colors, and short cooking times (Morris et al. 2007; Ritter et al. 2008; De Haan et al. 2019; Taylor 2019; Wijesinha-Bettoni and Mouille 2019).

There is value in an objective analysis of the many factors that affect the purchase and consumption of potatoes, including taste, cost, preparation time, convenience, familiarity, eye appeal, name recognition, and production conditions, such as locally grown or organic (Bamberg and Greenway 2019). The Commentary by Chef Emeritus Leif Benson (2019) addresses consumer expectations and how they change over time. It is not enough to determine whether a factor is simply positive or negative. Instead, it is necessary to identify the threshold at which a factor creates a significant motivation to choose to buy, even if the price is higher. It is also important to determine which positive factors may be based only on impulse or novelty, so they do not drive repeat purchases and adoption. As with any field of science, inquiry leads to more questions than answers. We hope this issue stimulates discussions and research efforts that will enhance our health through the consumption of potatoes.

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