SCIPOD

////Title: The Art and Science of Developing Safe New Crop Varieties

////Standfirst:

Many of the plant species that we depend on for food produce toxins. The wild ancestors of these crops relied on toxins to ward off diseases and prevent them from being eaten by animals. By choosing individual plants that lack the genes necessary to produce toxins, generations of selective breeding have produced countless crop varieties that are safe to eat. In a recent review, Natalie Kaiser from Michigan State University and her co-authors review the history of developing safe crop varieties, and discuss the special considerations given to plants that produce toxins.

////Main text:

For almost as long as humans have been farming, we have been selectively breeding superior performing plants for food, animal feed or fibre. By repeatedly selecting and breeding plants with desirable traits over many generations, crop varieties have been produced that are higher yielding, tastier, more nutritious, more resistant to diseases and safer to consume than their wild ancestors.

Although genetic modification technologies have been used to improve some crop species, the vast majority of the food crops that consumers enjoy are the product of selective breeding, also known as conventional breeding. Hundreds of new crop varieties developed through selective breeding are brought to the market every year.

While much attention has been given to examining the safety of genetically modified foods, there has been comparatively little dedicated to investigating toxin levels in selectively-bred crops. Natalie Kaiser at Michigan State University and her co-authors at Washington State University and Bayer Crop Science explored factors that contribute to breeding practices for developing safe food crops. In their recent paper, entitled ‘The role of conventional plant breeding in ensuring safe levels of naturally occurring toxins in food crops’, the authors review strategies used by plant breeders to ensure the safety of foods from selectively-bred crops.

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As described in their paper, crops can be broadly categorised into those that don’t produce any serious toxins, and those with known natural toxins. In the latter category, the safety of each crop depends on a number of factors, including the period of time the crop has been consumed safely, conventional breeding strategies used to select plants with low levels of toxins, and preparation methods that ensure safe consumption.

Some common foods that naturally produce toxins include celery, cassava, potato and rapeseed. The process of selectively breeding new varieties of these crops is similar to that used for crops that don’t produce toxins. In this practice, parental plants with desirable characteristics are bred together to produce offspring with new combinations of desirable traits. However, for crops that produce toxins, breeders closely monitor toxin levels during the process.

In the small number of cases where new food varieties have posed safety risks, the crop species were already known to be capable of toxin production. Kaiser and her co-authors found that there were no documented examples where conventional breeding practices led to new toxins being produced, or toxins not associated with the given crop. This is because selective breeding shuffles the genes from the parent plants, but does not give rise to new genes for producing new toxins. Therefore, breeders can refine their practices based on the known toxins in a given crop species, without the risk of new safety concerns.

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Understanding the chemistry within the edible part of a crop is vital for developing new varieties and food products that are safe for consumption. For example, fruits within the 'Rosaceae' (row-zay-see-eye – zay is the stressed syllable) family, including apples, almonds, apricots, peaches and cherries, produce a compound called amygdalin (ah-mig-dah-lin) within their seeds that can cause cyanide poisoning if eaten in large amounts.

Since the consumed portion of almonds is the seed, the amygdalin levels of all potential new almond varieties must be measured. In contrast, the intended use for new apple varieties determines the plant breeder's selection criteria. When apples are sold whole, their seeds are rarely eaten in sufficient quantities to pose any health risks. However, apple juice processing often involves the entire fruit, including the seeds. Fortunately for apple juice fans, testing has shown that processing reduces amygdalin content drastically, making it safe for consumers.

Kaiser and her co-authors explain that expanding food crops into new markets may depend on breeding efforts aimed at reducing the production of plant toxins. For instance, apricot seeds provide a source of dietary fibre and natural oils, but their use for human consumption is limited by the lack of varieties with low amygdalin levels.

In some cases, plant breeders have laboured for decades to reduce toxin levels in otherwise valuable food crops. Genetic technologies have provided breeders with additional tools for developing new crop varieties, including those with lower toxin levels.

For example, grass pea is a staple food in South Asia and Sub-Saharan Africa that excels in the harsh climates of these regions. However, grass pea naturally produces toxins that can cause neurological conditions. Researchers discovered genetic variation in the genes that control toxin production in this crop, which allowed breeders to concentrate their efforts to develop high-yielding, low-toxin varieties that are safe for eating.

Other widely consumed food crops, such as potato, are the descendants of toxin-producing wild relatives and have been improved by conventional plant breeding to produce safe varieties.

Identifying the genetics behind plant traits allows breeders to streamline the breeding process by choosing parents with the desired genes, even when the produced traits are visually indistinct. Commercial breeders often track traits across generations, allowing them to further examine how desirable characteristics are inherited. Additionally, broadly characterising the genetics of crop species may provide plant breeders with new targets for their breeding efforts. Alongside conventional breeding practices, Kaiser suggests that harnessing genetics in this way may become increasingly important to ensuring future food security and food safety across the globe.

This SciPod is a summary of the paper 'The role of conventional plant breeding in ensuring safe levels of naturally occurring toxins in food crops', from *Trends in Food Science & Technology*. https://doi.org/10.1016/j.tifs.2020.03.042

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