

The future of food



Engineered food has taken the step out of laboratories and started entering the market. However, whether engineered food technologies present a real opportunity for systemic change will depend on research advances, socio-political and economic considerations and acceptance by consumers.

Imagine sitting down to a dinner of 3D-printed steak with a nutrient-optimized side dish of rice and ‘health-promoting’ tomatoes, while sipping on a glass of lab-produced milk – such a meal is no longer in the realm of pure imagination, at least from a technological perspective. The way we produce and consume food has constantly changed throughout human history, often aligned with changes in the way we live, our agricultural practices and climate alterations^{1,2}. Today, [more than three billion people around the world cannot afford a healthy diet](#) and many of our food production processes have detrimental effects on the climate. Therefore, global food production, our consumption patterns and agricultural practices need to adapt to meet the food demand, democratize food distribution and ensure nutritional quality and ingredient safety while mitigating adverse environmental impact. Notwithstanding concerns about animal welfare.

Biotechnological and bioengineering tools are being developed to address some of these concerns by engineering plants, mammalian cells and microorganisms to produce food and food ingredients in a sustainable, environmentally friendly and animal-free way. Increasingly mature technologies, such as [genome editing](#), cellular agriculture and microbial-based food production, can be applied to produce healthier, sustainable and more foods with fewer resources and lower carbon footprint, creating an opportunity to reformulate food consumption patterns towards sustainable diets. Moreover, animal-welfare-conscious substitutes for meat and dairy are being explored, and [the first cultivated meat product \(cell-cultured chicken\) was approved in 2020](#) for commercial purposes by the Singapore Food Agency. In particular, animal-free products may have a substantial impact on reducing the environmental effects of food production given that [animal-source foods are responsible for the majority of negative outcomes on land use, water use, biodiversity and greenhouse gas emissions in global food systems](#).

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However, engineered food is often met with scepticism owing to the uncertainty that inevitably comes with the use of new technologies. Therefore, societal dialogue will be important to build trust, change mindsets, develop transition pathways and safeguard against undesirable effects³. Moreover, the price of the final product is a key determinant of how engineered food markets will evolve, and thus, more research is required to streamline and optimize engineered food production. Importantly, robust analyses of the feasibility of technological innovations and their potential effects are needed³.

This focus issue discusses technological progress and opportunities of engineered food technologies, including [genome-edited food](#), [cultured \(cell-based\) meat](#), [engineered microorganisms for food additive production](#) and [cellular agriculture for milk production](#). In addition, two start-up companies producing [silk-based food packaging](#) and [cultured meat](#), respectively, discuss the challenges of bringing their products to the market. Furthermore, in a [Viewpoint](#), two roboticists highlight the role robotics may play in transforming agricultural and cooking practices, and a [Comment](#) challenges the current scientific narrative of communicating new food and agricultural technologies to the public.

Defining the role that new biotechnologies may have in the future of food requires a broad conceptualization of food security, political economy and agricultural practice to ensure that technological advances translate into widely accessible and sustainable foods that are accepted by consumers⁴. Otherwise, 3D-printed meat and genome-engineered rice may well be produced – but would be neither affordable nor consumed. Whether engineered food becomes a game changer in the future of food will thus not only depend on technological advances, but also on how these are implemented and communicated in an economic and socio-political context.

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