

Science You Can Use

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Dear Science: I've heard that "burgers" can be made without using meat from a cow. Is that true, and if so, why would anyone want to do it? -- Buck R.

Dear Buck: Let's first look at what such "burgers" are, then look at a few reasons why someone might want to produce them.

"Burgers" that can be made without using "meat from a cow" can refer to several different products. In general terms, these products fall into two categories: vegetable-based products that to varying degrees resemble real hamburger, and a kind of beef tissue that at present has been grown only in small quantities in a laboratory.

Vegetable-based imitation- "burger" products. There are two more or less distinguishable vegetable-based imitation-hamburger products. One of these, which I will call a "low-tech veggie burger", is typically made from cooked, mashed cereal grains (e.g. bulgur) or legumes (e.g., lentils or soybeans), to which a binder (e.g., egg) is often added. To this base various seasonings, and optionally some chopped vegetables, are added. The resulting mixture is formed into a patty and fried.

Low-tech veggie burgers have neither the taste nor the texture of real hamburger.

The second type of vegetable-based imitation-burger product, which I will call a "high-tech veggie burger", typically contains products derived from cereal grains (e.g., flour) and legumes (e.g., soy protein powder), binders (e.g., egg products, guar gum, or starch) along with various seasonings. High-tech veggie burgers are specifically engineered to have flavor and texture similar to real hamburger. A few fast-food chains that sell real hamburgers also offer high-tech veggie burgers. (I have eaten a high-tech veggie burger from one of these establishments. In my opinion, the product tasted like, but was not as "chewy" as, a real hamburger.)

Beef tissue grown "in a test tube". A few years ago, scientists succeeded in growing batches of beef muscle cells in laboratory glassware. Let's call this material "wannabeef". The cells from wannabeef are derived from "stem" cells taken from cows. (Stem cells are general-purpose cells that are transformed into special-purpose cells (e.g., muscle, brain, and bone cells) in the normal course of an organism's development.) Scientists "programmed" the stem cells to develop into wannabeef, and the wannabeef then multiplied in a nutrient solution in laboratory glassware.

Wannabeef is a stunning technical achievement for at least two reasons. First, wannabeef is genetically identical to beef muscle tissue. Second, once the first batch of wannabeef has been created, even a tiny portion of that batch can be used to grow more wannabeef without ever touching a bovine. The amount of wannabeef that can be produced this way is limited only by the availability of the nutrient solution.

Wannabeef has been cooked and eaten by some of the scientists who produced it. They say that wannabeef tastes very much like lean “steak”, but it is not as “chewy” as steak or real hamburger. The difference between the texture of wannabeef and hamburger/steak is no accident: wannabeef contains no connective tissue, but hamburger and steak do.

To date, less than 100 kilograms of wannabeef have been produced. At present, wannabeef costs about one hundred thousand times as much as real beef to produce. (But prices are coming down.)

Why would anyone want to produce hamburger alternatives? The answers to this question fall into two general categories – diet management, and climate change concerns.

Diet management. Because by weight, hamburger can contain 10% - 25% fat, while veggie burgers contain about 5%, veggie burgers might seem preferable to hamburgers. There is more to the story, however. Ounce for ounce, beef contains twice as much protein as legumes. So, to get the veggie-burger protein equivalent of a quarter-pound beef patty, you would have to eat two quarter-pound veggie-burgers. Ounce for ounce, moreover, legumes are about 2.5 times as caloric as lean beef. When both these factors are taken into consideration, lean beef delivers four to five times as much protein per calorie as veggie-burgers do.

Climate change concerns. Given typical beef-production practices in the US today, on average it takes about 10 times as much fossil energy to produce an ounce of protein in the form of beef as it takes to produce an ounce of vegetable protein (e.g., from legumes such as soybeans, pinto beans, or lentils). Across the planet, the production of carbon dioxide, one of the greenhouse gases responsible for global warming production, increases approximately in proportion to the amount of fossil energy used. All else being the same, therefore, legume-protein production generates only about 10% of the carbon dioxide that beef production does, vegetable protein ounce per beef protein ounce. In addition, beef production is responsible for about 15% of the methane generated by human activities, and methane is a powerful greenhouse gas.

For further information, see (1) Intergovernmental Panel on Climate Change, *Land: Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*, 2019, <https://www.ipcc.ch/srccl-report-download-page/>; and (2) David and Martha Pimentel, “Sustainability of meat-based and plant-based diets and environment”, *The American Journal of Clinical Nutrition* 78, September 2003, pages 660S-663S, <https://academic.oup.com/ajcn/article/78/3/660S/4690010>.

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