

HOW SHOULD CALIFORNIA LEAD ON ALTERNATIVE MEAT?

A CALIFORNIA 100 POLICY BRIEF

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ALLISON BERKE
Director of Advanced Technology
California 100 and
Stanford Institute for Economic Policy Research



**VISION & STRATEGY FOR
THE NEXT CENTURY**



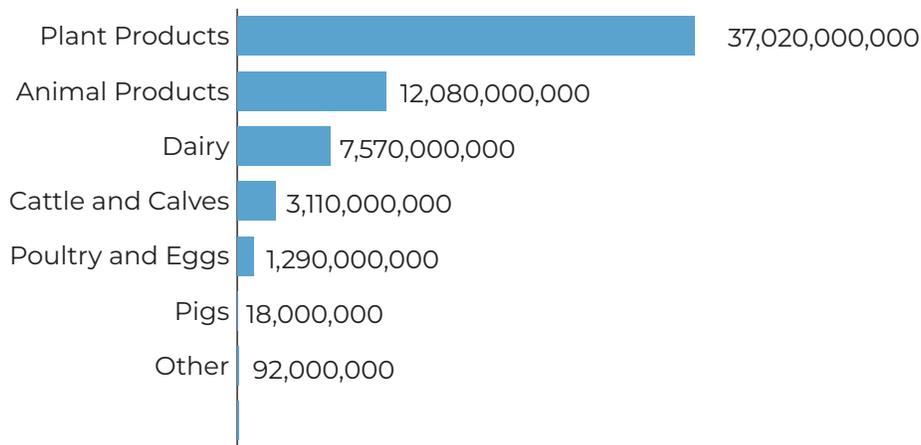
EXECUTIVE SUMMARY

California is a leader in food production and export, both to other states in the country and to countries around the world. Its animal-based food exports are heavily concentrated in dairy products and much less so in beef, poultry, and egg products. At the same time, the state is a national and global leader in production of high-margin plant-based foods such as almonds, walnuts, and avocados. With mounting concerns about climate change risk and water scarcity, California has the opportunity to take an early lead in alternative meat research, development, and commercialization. At the same time, advocacy by animal meat producers, inflexibility of consumer preferences, and

BACKGROUND

As of 2021, California produces \$12.08B in animal products: \$7.57B of dairy products, \$3.11B of cattle and calves (2.66B pounds), \$18M of pigs (36.8M pounds), and \$1.29B of poultry and eggs. The state exports \$2.037B of dairy products, \$413M of beef products, \$21M of chickens, \$13M of turkeys, and \$12M of eggs, accounting for 12% of the state's total agriculture exports. California represents 13% of US animal product exports, and primarily sends these products to Asia, Mexico, and Canada. Of the total amount produced, California exports 32% of its dairy products, but only 8% of its beef products and 5% or less of its poultry and egg products. Unlike products like avocados or walnuts, where California provides almost all of the nation's supply, its meat supply is more of an "eat what you kill" model; California also imports some meat products, but as meat imports are only reported on a national level, the precise amounts are not publicly available.

Figure 1. Value of California's agricultural production, annual amount (\$)



Californians eat approximately 59 pounds of beef per person per year, compared to a national average of 55 per person; Californians also consume 3 billion chickens, out of a national total of 8 billion. Being a coastal state, Californians have the highest per capita seafood consumption of any state, about 15 pounds per person per year, of which approximately 65% is imported. Despite a popular perception of being a health-conscious paradise for vegetarians, Californians for the most part are enthusiastic consumers of animal products.

California dedicates 16 million of its 100 million acres of land to livestock production including grazing, and 47% of its total water supply to meat and dairy production. California also props up international meat industries; 15,000 acres in Southern California are owned by a Saudi Arabian company, Almarai, and used to grow alfalfa, which is then shipped to Saudi Arabia to feed cattle.

Aside from ethical, health, and climate reasons to reduce meat consumption (livestock are directly responsible for 7-8% of all greenhouse gas emissions, and animal agriculture as a whole is responsible for approximately 15%), producing meat from animals uses a large share of California's arable land and drinkable water, which could be used more efficiently to feed more people more cheaply through plant-based products.

PLANT-BASED AND CELL-BASED MEATS IN CALIFORNIA

Despite overall consumption trends, California has long taken the lead in the development of vegetarian and vegan products and communities – from early vegetarian companies like Amy's Kitchen, founded in 1987 in Petaluma, to Berkeley's recent resolution to phase out city purchasing of animal products by 2024. In the related areas of food technology development for alternative proteins, plant-based meat and cell-based meat (also known as cultured meat or cultivated meat), California is also leading the way, home to 130 cell-based and plant-based meat companies (out of at least 1,187 globally, and 342 in the US), and billions of dollars of investment and company valuations across both industries. In fact, the two leading companies producing plant-based burgers, Impossible Foods and Beyond, are headquartered in California – Impossible Foods, based in Redwood City, CA, was founded by Pat Brown, a former Stanford biochemistry professor, and Beyond Meat was founded by Ethan Brown (no relation) and headquartered in El Segundo, CA. Eat Just, which sells plant-based eggs in the US and cell-based meat in Singapore, was founded by Josh Balk and Josh Tetrick in San Francisco, California in 2011.

Plant-based meat encompasses both the familiar veggie burgers and Boca burgers of the 90s and newer products that take advantage of advances in protein extrusion and texturization, protein isolation and processing, and the use of synthetic biology in the production of ingredients, like the Impossible Burger's plant-based iron-rich leghemoglobin, originally isolated from the roots of the soy plant, which gives the burger its "bloody" flavor. Meat products range in complexity from highly processed products like ground beef, sausage, bologna, or chicken nuggets, through products that are partially processed but retain some original structure, like canned tuna or shredded chicken, to products that are recognizably pieces of an animal, like T-bone steaks, salmon filets, or chicken wings. Plant-based meat, which is recreating taste and texture essentially from scratch, have been very successful in the first category (Beyond Burgers, for example, are replicating a ground beef patty that has lost much of the texture of the original muscle), somewhat successful in the second (particularly when using materials like jackfruit or oyster mushroom that have similar fibrous structures to muscle when used in small pieces), and much less successful in the third category. Products like Tofurky that mimic the shape and presentation of whole animal limbs or muscles are essentially molding a product from the first category into a visual facsimile, without accounting for the diversity of textures and flavors imparted by fat, cartilage, bone, and tendon.

Cell-based meat has yet to be approved for sale in the US (although it is available in countries that have moved faster to create regulatory pathways, including Singapore and Israel), but several California-based companies are already producing tens of thousands of pounds of product, from steaks to chicken breasts to salmon filets. Upside Foods, a cell-based meat company based in Emeryville, CA produces 50,000 pounds of meat per year, and has plans to scale up to 400,000 pounds per year within the next few years. Cell-based meat is produced by taking a small biopsy of tissue – usually muscle, although companies like Mission Barns (based in San Francisco) that produces cell-based animal fat would take adipose (fat) tissue – churning up and separating out individual cells, and then culturing, or growing, those cells in the same way a molecular biologist would grow cells in the lab. Once a sufficient quantity of cells has been produced, they are seeded on a scaffold to grow into the



right shapes and textures (think of the fibrous strands in a cut of steak, or the striations of muscle and fat in a cut of salmon sashimi). The process requires careful attention to the sterility and oxygenation of the environment in which the cells grow, continuous circulation of nutrients and removal of dead cells or superfluous molecules excreted by the cells, and a surface-to-volume ratio that promotes cells forming some small clusters but not clumping together so much that cells in the interior of a clump starve or are deprived of oxygen. (A common question about the process is whether growing cells requires an animal product, fetal bovine serum, that is sometimes used in research labs to culture cells – it does not, and cells can be grown with only plant-derived nutrients).

As with plant-based meat, growing cells into ground beef or the spongy chicken amalgamation in a McDonald's-style chicken nugget is straightforward, and producing small-scale structures like flakes and shreds is also fairly easy. The advantage cell-based meats have over plant-based meats is in producing those category-three meat products that require multiple layers and textures; because of the ability to direct and shape cell-based products through the use of scaffolds, and the availability of cell-based fats, producing larger “cuts” of cell-based meat is feasible. For example, Wildtype, a cell-based fish company based in San Francisco, produces a slab of salmon that slices into sushi cuts with recognizably authentic pink-and-white stripes and the pliant texture that allows a piece of nigiri to drape over a nugget of rice.

Current guidance from the FDA and the USDA is that cell-based meat will be jointly regulated by both agencies, though a process and criteria for approval to go to market have not been published despite a notice of proposed rulemaking published in 2021, and a recent “no questions” letter from the FDA given to Upside Foods’ cell-based meat, indicating that the agency considers their products safe for human consumption. The economics of cell-based meat currently point to a niche market, such as that for delicacies like sashimi or foie gras, products for which customers will pay \$30-40 per pound. Published prices are scarce, but as one point of comparison, the Israeli company Future Meat Technologies is producing cell-based chicken breast at \$16 per pound, though it also uses some plant-based fillers. Companies developing cell-based meat products anticipate scaling up dramatically, however, producing meat in brewery-like facilities with rows of vats, and obtaining currently expensive nutrients and growth factors from non-medical-grade sources that will lower the costs of these inputs.

Plant-based meat faces fewer policy hurdles, particularly in California, which has recently passed helpful legislation curtailing harmful practices in the meat industry, like gestation crates for pigs, force-feeding geese to produce foie gras, or cramped cage sizes for egg-laying chickens. However, other states have raised objections to labeling of plant-based products, arguing that consumers will be confused that “almond milk” or “plant-based sausage” contain no animal products. In 2019, the California Department of Food and Agriculture asserted that the use of the term “butter” on a vegan butter product violated California and Federal law, on the grounds that “butter” is a federally defined term. In 2021, in response to a countersuit, federal court in California ruled that the use of “butter” and similar terms is protected by the first amendment, regardless of Federal definition. Other labeling lawsuits have been decided similarly, with support from both vegan advocacy groups and free speech defenders like the Heritage Foundation.

While many of these challenges to plant-based meat marketing and product positioning are raised by cattlemen’s associations and meat-industry interest groups, the meat industry is also hedging its bets through investment. US meat producer Tyson Foods has invested in California-based alternative meat companies Beyond Meat, and Upside Foods (Cargill has also invested in Upside), as well as New York-based New Wave Foods and the Israeli company Future Meat Technologies. Nestle acquired Monterey, CA-based Sweet Earth Foods in 2017, and has invested in UC Berkeley-incubated Sundial

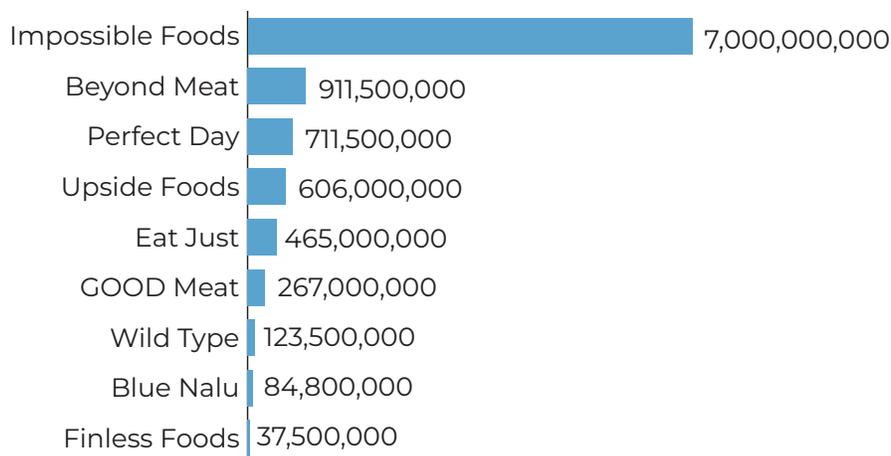
Foods. In 2021 alone, California-based beef processor Jensen Foods dedicated an entire facility to producing plant-based meat, San Bernardino-headquartered beef jerky producer Country Archer Provisions debuted a plant-based jerky, and Danone acquired the Los Angeles-headquartered plant-based dairy company Follow Your Heart.

R&D ON ALTERNATIVE MEATS

The backbone of innovation in food tech to produce these new products is research, and many California universities have demonstrated their interest and capacity in performing that research. California's 2022 state budget includes \$5M in research funding for cell-based meat development at UCLA, UC Berkeley, and UC Davis; the Agricultural Sustainability Institute at Davis already has a \$3.55M NSF grant for cell-based meat, as well as a Cultured Meat Consortium composed of 17 Davis faculty and \$4.1M of funding from NSF, the Good Food Institute, and New Harvest; UCLA has received over \$250,000 in funding to develop cell-based meat. UC Berkeley has a plant-based meat incubator on campus, including a class on alternative meats housed at the Sutardja Center for Entrepreneurship and Technology that has spawned several startup companies, including Prime Roots, Black Sheep Foods, and Sundial Foods.

However, public funding for cell-based and plant-based meat development is dwarfed by private investment. Global VC investment in plant-based meat was \$3B in 2021, and an additional \$1.4B was invested into cell-based meat companies. California has the most plant-based and cell-based meat companies of any state, and the most VC funding; the Bay Area is particularly dense with alternative protein innovators, many of which cluster around its research universities (Stanford, UC Berkeley, and UCSF). Within California alone, individual companies have raised impressive amounts of funding; Impossible Foods remains a private company, but is valued at \$7B; Beyond Meat went public in 2019 at a \$1.5B valuation and is currently valued at \$3.6B. Perfect Day, which makes cell-based dairy and is headquartered in Berkeley, has raised \$711.5M. Berkeley-based Upside Foods has received \$606M in funding, Eat Just, a San Francisco-based company, has received \$465M in funding, and its subsidiary GOOD Meat has raised \$267M. San Francisco-based Wild Type has received \$116M, San Diego-based cell-based fish company Blue Nalu has raised \$84.5M, and Emeryville-based Finless Foods has received \$37.5M.

Figure 2. Total private funding received by California alternative meat companies





Plant-based meat is a \$1.4B business in the US, and all plant-based products (including products like almond milk, tofu, and tempeh) is a \$7B market in the US. The California specialty foods industry, which encompasses organic and “natural” foods as well as plant-based foods, is a \$3B market. Plant-based meat sales represent 1.4% of the total meat market (which includes both packaged meat and meat sold-by-weight); California’s \$4.51B production of animal products mean plant-based meat sold in grocery stores in California is approximately a \$63.1M business. This is roughly the amount of funding raised by cell-based fish company Blue Nalu in 2021 alone, indicating the venture industry’s enthusiasm about the potential growth of alternative meats in California and beyond.

The profitability of the animal-based meat industry depends on the multiple streams of revenue derived from a single animal – veal calves produced from the continuous pregnancies necessary to keep a dairy cow producing, leather from hides, gelatin from cartilage, animal food from meat processing remnants, stearic acid for use in cosmetic and medical products, and more – 34% of a beef cow by weight is used for products other than beef. Removing any one of these follow-on sales makes the production of meat for human consumption less profitable; removing several at once may make it unsustainable. The byproduct value of cattle and pigs in 2021 was \$15.83 and \$5.59 per hundred pounds, respectively; for cows, half of that value is the hide, and the byproduct price is approximately 11% of the total price of the animal. With a profit margin of \$137 per animal, and with an average weight of 1200 pounds, that’s \$11.42 of profit per hundred pounds. Where exactly the tipping point comes depends on how willing governments are to subsidize meat producers, and how much of the market a replacement vegan source of, e.g., leather or gelatin can capture, but there is a conceivable path toward a food economy in which meat produced from animals is a niche product, and cell-based and plant-based products predominate.

CONCLUSIONS AND RECOMMENDATIONS

The alternative meat industry is dynamic and growing, and California has an inherent advantage in the development of these products as a result of the high concentration of plant-based and cell-based meat companies and university research funding in the state. While California’s recent \$5M allocation for research funding for cell-based meat development at UCLA, UC Berkeley, and UC Davis is a useful first step, the amount of funding that has been dedicated to alternative protein R&D pales in comparison to the billions of dollars a year in government funding that have been allocated to R&D for clean energy technologies like biofuels, solar energy, wind power, and geothermal energy.

California could take three concrete steps to encourage and accelerate the development of cell-based and plant-based meat.

First, the state could dedicate funding to the cell-based and plant-based meat sector, taking as a guide the investments of countries with similar economies to California (which is the world’s fourth largest economy). The United Kingdom has invested \$108M in alternative proteins, Australia has invested \$177M, and Canada has invested \$133M. As a percent of agricultural GDP, the largest investors range from Singapore, at 45%, to Sweden, at 0.13%. Assuming an investment similar in scope to that of the UK, that would mean California would commit to investing 0.60% of its agricultural GDP in alternative proteins, or \$294M. This funding could support the development of cell-based and plant-based meat research, companies, supply chains and distribution channels, and purchasing programs for state and local facilities like schools, healthcare facilities, and correctional facilities to purchase and serve alternative proteins.

Second, Governor Newsom could add alternative protein production and consumption targets to the \$54B California Climate Commitment, aiming to replace 50% of animal proteins produced and consumed in California with alternative proteins by 2045, in alignment with the Commitment's greenhouse gas neutrality target. The production of animal proteins contributes to greenhouse gas emissions, deforestation, and pollution, and current methods of producing animal proteins are unsustainable to meet projected demand growth. By adding alternative protein targets to California's climate change action plan, the state could acknowledge the role of animal agriculture in accelerating climate change, and incentivize multi-sector solutions to scaling and improving cell-based and plant-based meat production in the state.

Third, California could build on SB 1148, a law signed in 2018 requiring state-operated facilities to offer plant-based meals. Expanding SB 1148 could increase the 2022 state budget's allocation of \$100M to support schools in procuring plant-based, sustainably produced, and California-grown foods, and expand funding to support all state-operated facilities in procuring plant-based foods. The state could also revive Assemblymember Kalra's 2021 bill AB 1289, which would provide grants to livestock and feed crop farmers that would allow them to transition to growing plant-based foods and plant products for human consumption. These efforts would further enshrine California's commitment to sustainable agriculture and procurement processes, and help farmers move toward more environmentally friendly practices.

As an agricultural, climate, and technology leader, California has the opportunity to make a significant investment in developing a new industry that will not only create engineering, biotech, and Ag Tech jobs in the state, but also accelerate the production and adoption of products that will ameliorate the state's strained climate and water supply.

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