

PROTEIN EQUIVALENCY

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For most people, meat happens to be incredibly tasty and nutritious, and perhaps the only way to successfully replace it is to develop a superior plant-based product that is equally good in organoleptic performance, such as taste and texture. Plant-based burgers such as those marketed by Impossible Foods, Beyond Meat, and Nestle's Garden of Eatin', are well on their way being at par with the beef burger equivalent.

There are major differences between animal meat and "plant-meat". Plants typically contain a smaller percentage of protein, while animal meat has an abundance of high-quality protein and a great vitamin and mineral profile. These differences need to be harmonized. To increase the protein content of plant-based meat alternatives, ingredients are routinely selected, of which the protein components are extracted, concentrated, and often enzymatically modified. These modified plant proteins are sometimes used as a powder to bind fat and water, but most often, are in an extruded form to create the much-needed appearance and texture.

Yeast: Flavor and Aroma is Key

Other major differences are the flavors and aromas of plant meat, which is especially true when mimicking beef. When real beef is cooked, literally hundreds of different aroma compounds come through and together create the ultimate taste humans prefer. Flavor and aroma are the golden standard for comparison and quality reference. It is no doubt that the flavor and texture of meat are hard to replicate. That is, by far, the biggest hurdle for the meat alternative products to overcome.

Designer yeast ingredients provide natural flavor bases and umami richness, bringing out a savory perception. The masking properties of designer yeast extract, neutralize plant protein off-notes, including beany, metallic, and astringent undesirable flavors (that often linger long after the plant-meat alternative has been eaten).

Yeast has been around for many centuries and is used by nearly all food companies as an aromatic

stimulant to improve taste in foods, beverages, and plant meat alternatives. Yeast extract is the yeast content without the cell wall. Yeast is a micellular micro-organism belonging to the fungus family. Yeast extract is a natural origin ingredient derived from fresh yeast. The macro-molecules of the cells are divided into smaller molecules that deliver the protein portions such as peptides, free amino acids like glutamic acid, nucleotides, and glucans.

Formulating plant-meat alternatives may bring challenges for taste, texture, color, and odor. This is especially the case if natural label specifications are needed for positive consumer expectations, such as the elimination of chemically sounding additives. Yeast formulated ingredients are now an important tool to create the desired taste profile. Yeast extracts typically contain proteins, free amino acids, carbohydrates, vitamins, and minerals.

These "vegan" ingredients fit perfectly in consumer products that need a natural label. Most plant-based meat products contain nucleotide yeast extracts, which function as a mask to the beany off-flavors that are inherent in plant-origin proteins like pea and soy protein. Yeast extracts are now routinely used delivering additional properties, like meat notes and umami flavor. Yeast extracts are also used to imitate the taste of the various product types that are smoked, roasted, or grilled.



Yeast modulated flavors are by far the most expensive ingredient used in plant-based meat alternatives. Obviously, these yeast flavors are mainly chosen for their ability to mask the off notes of the plant proteins. Incidentally, potato protein -when used in the formula- is the second most expensive ingredient and is likely to get taken out of the ingredient line-up when alternatives become available.

Fat is Essential

Animal adipose tissues are composed of fatty cells in a collagen fiber network, making their structure difficult to replicate with plant oil and -fat. Animal fats have higher melting points than plant-derived oils, providing a solid structure that slowly melts while cooked. Ideally, plant oils and fat should have similar melting characteristics as animal fat. Fortunately, significant progress is made in creating animal-fat substitutes, including fermentation-derived and synthetic fats for use in plant meat alternatives. Native plant lipids can be combined with ingredients like proteins, carbohydrates, and phospholipase to entrap oil without modifying their chemical traits. Both sunflower and coconut oil are good options to create stable emulsions with key microstructure and thermal properties, as well as rheological and texture similarity of adipose tissue from animal sources.

Fat Mimicking

As a fat source, a thermosensitive ingredient will be needed to help



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with the fluidity. Usually, coconut fat is used to deliver organoleptic preferred quality, as well as functioning a "sizzling" source in a burger. For 3D printed plant-meat products, cocoa butter, sodium alginate and polysorbate are emerging ingredients to make the plant meat "dough" more fluid at warm temperatures. All of this is within a network of -for example- soy protein, barley protein and wheat gluten that help ensure the much-needed fibrous properties. 3D printing technology for plant-based meat products are used alongside computer controlled robotic lasers to assemble the final shapes.

The biggest hurdle to take is the development of a plant-based fat compound that mimics animal fat release during thermalization to create the juicy taste and succulence of the burger. It is

rather difficult to find the ideal combination of plant fat aromas and taste to emulate the melting and mouth coating properties of animal fats -especially beef fat. As the fat melts during the cooking of the burger, it transforms into a flavor sensation delivery system, which provides sustained release of taste and aroma components to create the much sought-after meaty lingering effect.

Perhaps the holy grail is using cell-cultured beef fat or synthetic fat as the main flavor contributor in vegan or vegetarian burgers. A small percentage of -say 4 percent- cultured beef fat will enormously improve flavor sensations. Mosa Meat is leading the pack for cell-cultivated beef fat production. The wait is for government regulators to decide on the labeling status of cell-cultured fat.

An emerging method to manufacture fats and oils in foods is the oxidation platform technology -debuted by Savor- that requires no agriculture. This technology uses a carbon-based source such as natural gas, municipal solid waste, or CO₂ to create fat and oil formulations for plant-based foods. The method can truly mimic "real fat compounds" such as stearic, palmitic, lauric acid, and triglycerides.

Textural Density

Texture, flavor, and color are the driving forces when it comes to using plant-protein ingredients to mimic meat. It is a fine art to duplicate the textural and flavor subtleties, such as chew and fibrosity of the meat or the flakiness of plant-fish.

Both plant protein ingredients and support additives, such as plant fats and oils and methylcellulose and konjac flour, are usually modified to create textural density. For marbling and sizzling, coconut fat and/or palm oil is usually part of the product composition and used to simulate melt and tenderize properties just like a traditional burger beef. Common plant-based fats include those high in saturated fatty acids, such as coconut oil, palm kernel oil, and palm oil. These oils are more solid in structure and less prone to oxidation. Oil sources support lubricity to help simulate mouthfeel of animal-based products, as well as regulate moisture release and stability. The amount, type, and properties of fat are important factors in achieving the desired

sizzle during cooking and delivering juiciness when eating.

Animal meat flavors develop at different rates as fat, connective tissue, and meat cook. The maillard caramelization of carbohydrates and proteins creates hundreds of flavor compounds during cooking or grilling. Arguably, people who have switched to plant-based meat analog foods have somewhat debased their flavor and eating sensations, hence may have forgotten what an actual pure beef burger tastes like.

Even when plant protein-formulated meat equivalent products reach a high degree of flavor, aroma, and texture equivalency with the real McCoy, still one major component is still missing: blood. Of course, there is no real blood in raw meat but rather a combination of myoglobin and some extracellular water that creates the reddish looking meat juices.

The 3D Plant Steak

Sensorial parameters for plant meat equivalency are important to recreate whole-muscle beef texture, juiciness, chew, mouthfeel, and fat distribution. The arrival of 3D precision printing technology to achieve texture, color, and flavor embedded in intimate interactions of the individual components will accelerate the go-to-market time. Using separate innovative ingredient compositions for "plant muscle", "plant fat", and "plant blood" will allow the creation of steak analog products that will



provide consumers the experience of eating food that simulates whole muscle meat, which meat-lovers embrace but just happens to be vegetarian.

Redefine Meat is world's first company to commercially market 3D-printed "plant meat" that bleed like traditional beef and truly simulates the texture, chewiness, mouthfeel, and eye-appeal of traditional animal steak cuts. These 3D-printed plant meat products allow roasting, grilling and even slow-cooking and thus are versatile options for vegans and flexitarians alike without compromising quality.

Texture: From Past to Present

The journey from tofu - "meat from the field" - to extruded structured meat analog ingredients has taken more than 2,300 years.

Extruded structured plant protein can successfully replace lean meat. Traditional textured defatted



soy flour (50 percent protein) is considered merely a filler without real textural improvement. However, textured plant protein products are increasingly formulated from protein concentrates -rather than from protein isolates- in a combination of support ingredients like potato starch and/or wheat gluten.

Furthermore, gluten-free vegan options have become a reality. There is a certain plant-meat alternative market that is focusing on gluten-free pea or soy protein ingredients. These textured ingredients are ideally formulated with a minimum of 60 to 70 percent protein on a dry basis, with significant functional benefits such as hydration capacity, clean flavor, and textural properties.

Premium plant-meat alternatives look like real meat when cooked and can be pulled into shreds, or appear as minced or crumbled, or used as part of an emulsified vegan sausage like the hotdog and bologna.

At a molecular level, everything from an animal's lean and fat tissue can be replicated using plant fractions instead. Structured plant-based meat is a manipulation of plant protein and other ingredients to perfectly mimic the texture, appearance, consistency, and nutritional approximation of cooked meat.

Hybrid Anyone?

A possible future scenario is blending extruded and structured plant protein with a portion of animal meat or cell-cultured meat. These products can be termed "hybrid foods". Hybrid concepts in food, beverage, and meat products are taking a variety of formats, including fusion, and blending both animal and plant protein components. In the Western world and affluent societies, these hybrid foods generally focus on health, dietary, or flexitarian elements. In developing countries, hybrid is nearly always associated with the need to significantly reduce food costs, thus making the product more affordable for the masses.

In the Western world, the blended or hybrid protein trend is in vogue. For these markets, "hybrid" foods can be defined as products in which animal and plant proteins are combined, offering enhanced nutrition. Part of this trend is the transformational change from side dishes to more of a center-of-the-plate presence at mealtime. In other words, side dishes will go from meal compliments to meal makers. This change is coupled with people aged 30 and below

who have a habit to snack at all hours. These changes result to people eating more snacks throughout the day, which creates demand for flexible food options, including single-serving portions, that can be eaten anytime.

The Hybrid Spirit

Entrepreneurial-driven companies are radically changing the concept by applying post-animal biotechnology and bioeconomy technology to mimic animal meat characteristics or simulate traditional foods. Examples of which are animal-free or "cow-free" whey protein such as lactoglobulin, and "chicken-free" egg albumen. These innovative technologies or cellular agriculture will ultimately revolutionize current food production models.

The (hybrid) technology will grow to formidable importance and will be the key to the future of our planet - a sustainable and ecologically friendly system to nourish people at an affordable price. In the future, companies are expected to build their own in-line manufacturing units to structure plant protein to augment meat. This will significantly stretch the available animal protein sources to feed the rapidly growing populations. This way, developing countries can become more self-supporting in food availability and security. In a few countries, these modern versions are already in operation and are being showcased by manufacturing facilities producing extruded structured plant protein ingredients. ●