

TRANSFORMATIONAL PLANT MEAT FORMULA

By Henk Hoogenkamp

The transformational road to concoct a “veggie burger” that is juicy and flavorful with the right bite and texture is quite long and not easy to navigate. Fortunately, with the arrival of cellular agriculture and improved extrusion knowhow, major development hurdles can now be successfully taken. In fact, assembling certain compounds and ingredients from plants allows for a more level playing field when compared to the traditional formulated meat products, like burgers and chicken strips.

The Covid-19 pandemic resulted in a significant shift in consumer behavior from food service and restaurants to grocery shopping, accelerating to unprecedented retail demand. In a matter of only a few years, both Beyond Meat and Impossible Foods have become the world’s most recognizable brands in the plant-based meat market. Both companies - as well as some late entry legacy companies - are dramatically expanding the retail and footprint of the mail order supply chain offering versatile and convenient products, including 500 gram “bricks” of ground “plant-meat” for home cooking.

The Need to Diversify

To meet country-specific regulations, plant-meat companies such as Beyond Meat and Nestle have various product iterations. For example, co-manufacturing facilities for the Beyond Meat burgers in Canada and the Netherlands use different formulas than their US flagship product.

In order to secure supply and costs of its core protein ingredient, it is likely that the large “plant meat” companies such as Impossible

Foods, Beyond Meat, Morning Star Farms (Kellogg’s), and Nestle, forge closer relationships with their plant protein suppliers. In addition, it can be expected that these companies want to diversify the plant protein options in their products to minimize dependence on just one crop. At this moment, both soy protein and pea protein are clearly the plant proteins of choice with some other emerging options such as mung bean, fava bean, rice protein, and chickpea protein gaining momentum.

Quality & Perception

Both the quality and availability of “meatfree” meat analogs or meat substitutes have improved significantly over the last few years. Despite the flavor masking challenges, plant-based proteins continue to grow in popularity. The current baby boom generation (born 1946-1964) will most likely be the first and last generation that consumed meat every day.

Rising health awareness and shifting dietary preferences will

generate increased demand for meat analogs. These “lifestyle foods” practices, including veganism and flexitarianism, have been edging into the mainstream options.

In the US, flexitarians outnumber vegetarians 3 to 1 and the EU is following closely behind. Germany and the UK have the highest penetration of the flexitarian consumers and the trend is accelerating to double-digit growth to drive the market for plant protein forward.

Flexitarians are a rapidly growing consumer segment aiming for transformative change, albeit often driven by psychologically and emotionally inclined aspects associated with animal welfare. Also, young and adolescent girls going through puberty often decide spontaneously to stop eating (red) meat.

Consumers have multiple motivations to embrace a plant-based diet, driven by personal and planetary health, including considerations for wellbeing, environment and sustainability, as well as personal



convictions such as religion or animal welfare.

Although -until to date- there is not a set definition of a plant-based diet, plant-based eating is gaining momentum, probably with the help of the fashion and entertainment industry, which endorses a lifestyle in an inspirational and modern way. The Impossible Burger and the Beyond Meat range of plant meat foods are appealing to a much larger segment of modern consumers who have started to make food choices based on organoleptic preference, health and environmental concerns.

As such, a new type of consumer is emerging, and this category can be identified as “flexitarians”. This motivation to purchase plant-based meat options is not necessarily due to an increase in strict vegetarian diets. Instead, the flexitarian consumers view plant-meat alternatives, not as a replacement for meat, but as an occasional and acceptable nutritious and tasty option.

Vegetarianism appeals to surprisingly few people. The true growth of meat substitutes or plant meat foods comes from flexitarians. The latter group consciously eliminates or reduces animal meat from their daily line-up of food and plan for it only a few



times each week. When explaining reduction of meat consumption, health is the most cited reason, followed by environmental and animal welfare concerns. Religious reasons are the least cited for cutting back on meat consumption. Eating much smaller portions of meat is the most popular way to reduce meat intake. “Flexitarians” specifically choose to eat smaller portions by substituting vegetables, or they eliminate meat altogether from some meals and instead eat “plant-meat” foods.

Climatarians

Within the plant-based food preferences a new sub-group is trending in the form of “climatarians” or people who are truly worried about environmental issues. Climatarians are conscious of the impact of the globalization of food production and consumption in relation to the planetary health. Within this context, climatarians profoundly believe that regionalization of food production and consumption are the way forward in delivering the products to the market.

Grass = Gas

Humanity needs to feed a fast-increasing global population, and the planet should not be burdened with ever more livestock. Besides the unfathomable amounts of feed and water and land needed, cattle methane emissions are estimated to make up about 10 percent of greenhouse gas emissions worldwide.

In terms of ecological food sustainability, industrial scale feedlot meat production is probably the world’s largest environmental problem. Reducing meat consumption will free up vast amounts of land and water. Beef is generally considered the worst part of the meat pyramid because of its very inefficient feed-to-meat conversion and the use of huge amounts of clean water during the outgrow cycle of the animal. Yet, on a worldwide basis, more than 50 percent of all beef is ground and ends up as a hamburger.

However, to be fair minded, a significant number of cattle grazes on non-habitual unproductive agricultural land and as such



Impossible™ Burger, delivered!



contribute to the maintenance of main parts of the geographical infrastructure.

Meat happens to be incredibly tasty and nutritious and perhaps the only way to reduce consumption is to develop a superior plant-based product that is at least equally good in organoleptic performance. The recent introduced plant-based burgers and sliders such as Impossible, Beyond Meat, Garden Gourmet (=Nestle) and Moving Mountains are well on their way to get to par with the meat burger equivalent.

There are major differences between animal meat and "plant-based meat". Plants typically contain just a few percent of protein, while animal meat has an abundance of high-quality protein and a great mineral profile. These differences need to be brought in line and harmonized.

Another major difference are the flavors and aromas of meat, and this is especially true for beef. When beef is cooked, literally hundreds of different aroma compounds come through and together create the ultimate taste humans prefer, which is the golden standard for comparison and quality reference. No doubt that flavor and texture of meat is hard to replicate. That

is by far the highest hurdle for the meat alternative products to climb.

Health or Environment?

The verdict is still out with regards to answering the question whether personal health or the concern for climate change is the main reason for increased numbers of people in developed countries actively reducing their meat intake.

Some surveys indicate that health is still the main reason as some scientific studies demonstrate a connection between high processed meat consumption and several degenerative chronic diseases. On the other hand, an increasing number of people -especially the younger generations- are predominantly influenced by the constant barrage of anti-meat publicity from the media raising concerns about climate change.

Yeast: Flavor and Aroma is Key

Besides labeling issues, formulating plant-based meat alternatives may bring challenges such as texture, color, odor, and taste. This is especially the case if all-natural label specifications are needed for positive consumer expectations, such

as the elimination of chemically-sounding additives.

Typically, yeast extracts contain proteins, free amino acids, carbohydrates, vitamins and minerals. These "vegan" ingredients fit perfectly in consumer products that need a natural label, while meeting all sustainability considerations. A main component of plant-based meat products are nucleotide yeast extracts that perform to mask the beany off flavors typically associated and inherent of plant-origin proteins. To further improve upon water-binding performance and improved juiciness, gellan gum is often part of the ingredient deck as well.

Increasingly, yeast extracts are used with specific characteristics like meat notes, umami flavor, while at the same time masking undesirable notes that often are associated with certain plant protein ingredients such as soy and pea. Yeast extracts are also used to imitate the taste of the various product types that are smoked, roasted or grilled notes.

Meat flavors develop at different rates as fat, connective tissue and meat cook, and subsequently, the maillard caramelization reaction of carbohydrates creates hundreds of flavor compounds during heating. This is a very difficult problem to solve for the vegetarian burger formulators. However, let us pause for a moment and recognize that true vegetarians and perhaps flexitarians, have debased their flavor and eating sensations. Quite a few perhaps do not know or have forgotten what an actual pure beef burger taste like.

Even when plant protein formulated meat equivalent products reach a high degree of flavor, aroma and texture equivalency with the real

McCoy, there is still one major component missing from the burger attributes: 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.

Oil Secrets

At a molecular level, everything from an animal's lean and fat tissue can be replicated using plant fractions instead. For example, the "plant fat" can be replicated by using several methods. One specific technology is to structure coconut oil with extruded plant protein and pea protein - or potato protein - to entrap the fat. When heated on a grill the plant fat begins to melt, very similar like beef fat.

Texture and color are important variables when it comes to using plant-protein ingredients to mimic meat. It is a fine art to duplicate the textural subtleties, such as chew, fibrosity and flakiness of the meat or fish. Proprietary innovative manufacturing and formulation technologies have become available and are now increasingly used for animal-protein replacement.

Plant protein ingredients, as well as support and modification additives such as plant fats and oils and methylcellulose and konjac flour -a fibrous root vegetable with a rubbery texture/consistence- can be modified for varying degrees of textural density to meet consumers' expectations.

To simulate beef fat for marbling and sizzling, both coconut fat and cocoa butter can be used to melt and tenderize, much like a ground beef burger. 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 stability. The amount, type and release of fat are important factors for achieving the desired sizzle when cooking and juiciness when eating.

Consumers at Turning Point

By far, most of the people who purchase plant meat products are meat eaters, this category is universally termed "flexitarians". It is a definite sign of the times that even very traditional UK and German meat companies are now entering the market for meat substitutes. Trends seem to indicate that meat alternatives sales in affluent markets are developing at the expense of meat: Meat analog sales are expected to accelerate further continuing double-digit sales growth, whereas meat sales in affluent countries will stabilize or even slightly decline.

The plant-based meat alternatives are a category that is outpacing growth in the broader packaged foods sector. Strangely, most of the sales growth of plant-based

meat products does not come from common vegetarians, but rather from the Millennial consumers (born 1982-2004) and their children who facilitate a long-term habitual change in consumption patterns.

Hybrid Anyone?

Hybrid concepts in food, beverage and meat products are taking a variety of formats, including fusion and the blending of two or more different protein components. In the Western world and affluent societies, hybrid foods are generally focusing on health, dietary or flexitarian elements. In developing countries, hybrid is nearly always associated with the need to significantly reduce food costs and thus to make 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 especially obvious

for millennials and Generation Z, increasingly snacking at all hours by substituting a snack for a meal. These changes result in people eating more fluidly throughout the day, which creates demand for food options that can be eaten anytime.

Global Perspective Soy: A Missed Opportunity

It remains a mystery why the rather conservative US soy protein industry had a lackluster attitude about the necessity of product innovations to further advance the market. Instead, they took the easy way forward and carried on using dated technology of extruding defatted soy flour - limiting its applications due to flavor constraints - and continued maximizing inclusion levels which clearly did not impress consumers. Even though consumers showed a strong dislike due to negative perceptions and flavor associations, until the year 2000, the soy protein industry did little or nothing to make the necessary changes to improve technology and develop better tasting extrudates made from soy concentrate rather than soy flour. The large soy companies are now facing a new landscape in which they are no longer considered a pioneer but have become followers in a market they once dominated.

Meat Ingredient Options

Computational science application is increasingly successful in determining values of plant species, such as those present in soy, wheat, corn and rice, as well as finding combinations to create nutritive and great tasting sustainable sources of protein and other bioactive phyto-compounds.

Combining the virtues of plant protein and technology has unlocked the secret to create near-perfect replicas

of muscle meat. These meat analog foods are formulated using plant proteins derived from wheat, soy and pea using a structuring process that uniquely creates and mimics meat-like alignment and fibrosity. This technology breaks away from the typical, outdated extrusion processes of meat substitutes -such as the rather old-fashioned textured soy flour-which often lacks the fibrous texture moisture retention and has poor flavor. Increasingly textured plant protein products are formulated from a combination of several protein concentrates such as soy and wheat gluten and potato starch.

Structured plant protein foods have a lot of advantages: no cholesterol, no trans fats or saturated fat, and are made of plant proteins free from antibiotics and hormones that are so typical for lean meat. Also, gluten-free vegan options have become a reality. There is a certain plant-based meat alternative market that is focusing on gluten-free pea or soy protein ingredients. These textured ingredients ideally are formulated with a minimum of 60 percent protein on a dry basis, as well as significant functional benefits such as hydration capacity, clean flavor and textural properties.

“Perception is Reality.”

To gain acceptance from mainstream consumers, the meat alternative should ideally be just as a convenient, tasteful, and ultimately even cheaper than the animal meat protein product. Over time “plant meat” products are expected to be cheaper than animal-harvested meat products.

For premium plant-based meat analog foods, the Holy Grail are products that look like real meat when cooked and can be pulled into shreds, or appear as minced or crumbled, or used as

part of a coarse or emulsified vegan sausage like a breakfast sausage, bratwurst or hot dog.

The 3D Plant Steak

The successful replication of beef steaks is one of the remaining holdouts which the plant-based meat industry still needs to conquer. Sensorial parameters for plant meat equivalency are important to recreate premium beef cut’s 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. Also, recently developed “flat” extruded plant protein components will allow “layering” of the hydrated extruded portion which enables the creation of true steak-appearance. Using separate innovative ingredient compositions for “plant muscle”, “plant fat”, and “plant blood” will allow the creation of meatfree products that are not only healthy and sustainable, but also provides the consumers the experience of eating a food that simulates whole muscle meat alternative products that meat-lovers embrace and just happens to be vegetarian.

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