ALTERNATIVE PROTEINS

Protein Innovators Look Beyond Meat

It is clear that innovative extruded structured plant protein products have reached a high degree of technology, which enables a successful synthesis of authentic meat texture.

by Henk Hoogenkamp

By 2050, global meat consumption is expected to increase by a staggering 40-50 percent compared to 2016. Growth in population and disposable income will accelerate meat consumption for the foreseeable future. The growth curve of meat consumption has risen from 110 million metric tons in 1975 to about 320 million in 2014, and could reach some 470 million metric tons in 2050 (FAO: How to Feed the World in 2050).

It will be essential to develop an economically, ethically and nutritionally viable source of meat for the well-being of people. On the horizon is cultured meat made from laboratory-grown bovine skeletal muscle stem cells, as well as edible insects that can stretch the sustainability and availability of animal protein, without further damaging the environment. From a nutritional standpoint, insects are comparable to livestock. A major reason for considering high-quality insect protein is the nutritional, economic and environmental impact, while the biggest advantage is that insects are also very efficient in converting agricultural food waste to useful animal protein. Still, many questions remain to be answered before insect protein becomes mainstream. One of these questions is ethical in nature and another whether the genetic make-up of insects might negatively influence long-term human health.

SOURCE: INNOVA MARKET INSIGHTS

› *Gardein Seven Grain Crispy Tenders (Australia) features the claims: GMO free. Soy, wheat and canola free. Certified kosher. Suitable for vegan. Dairy free. Meat free.*

However, the real future for innovative technologies is blending structured plant protein with a portion of animal meat (including "cultured" meat), which is formulated to wholesome and good-tasting foods. These products can be termed "hybrid foods" or used solo for wholesome meat-free foods. It is clear that innovative extruded structured plant protein products have reached a high degree of technology, which enables a successful synthesis of authentic meat texture.

Entrepreneurial Spirit

Entrepreneurial-driven companies like Brecks Food UK, Gardein BC Canada, Beyond Meat, Impossible Foods, Hampton Foods, Modern Meadow US, and Food-Flow Philippines have radically changed the concept of structuring plant protein technology to mimic meat characteristics and significantly improve the structure, texture and flavor and nutritional profile, by incorporating other grain varieties such as wheat and quinoa.

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, countries are expected to build manufacturing units to structure plant protein to augment meat, thus significantly stretching the available animal protein sources to its optimum qualitative and quantitative standards to feed the rapidly-growing populations. This way, developing countries can become self-supporting in terms of food availability and security. In a few countries, this modern version is already in operation and is being showcased by manufacturing factories producing structured plant protein ingredients and working together with further-processing companies specializing in hybrid foods and meat-free food.

The future will probably look different from today, even though many meat-processing companies are obsessed with driving-out costs by targeting lean meat replacement as an obtainable goal.

The question is not "if" but "when" the world will reach the junction where the use of lean full-muscle meat in emulsified sausages and all-beef hamburgers can no longer be sustained. When that point arrives, meat processors have no other alternative but to embrace transitional plant protein ingredients to augment meat products. The leading transitional proteins are derived from soy, wheat, pea and rice.

Plant Meat Nutrition

Plant protein structured products have a high nutritional value and typically absorb 2 to 4 parts of water, thus truly duplicating lean meat composition. This allows for considerable cost savings when compared to lean beef, chicken and tuna. Plant protein sources are more reliable and stable in price than meat, and they also allow sustainable sourcing, including huge energy savings on refrigeration, logistics and warehousing.

The bottom line is that by adding 5 percent of structured plant protein and 20 percent hydration water (1:4), an astounding 25 percent of meat equivalent can be replaced in almost any formulated coarse ground meat product. Swapping only 25 percent of meat for hydrated structured plant protein will make a huge difference for the planet.

Going Forward in Proteins

Especially in developing countries, meat consumption is expected to rise sharply. This is mainly due to improved living standards, including a higher financial status and improved health. There are also unsettling environmental and health consequences to consider. These include loss of biodiversity, higher greenhouse gas emissions, water pollution and deforestation. However, it is futile to expect that

meat consumption will decline, though with a concerted effort it will perhaps be possible to reduce the growth curves.

Analog or Hybrid

Innovative structuring technology has become available using plant-based protein ingredients that are dried immediately after extrusion. These products are hydrated before use at prices significantly cheaper than meat. This form of extrusion is growing at a much greater speed than high-moisture processing. For now, a few entrepreneurial-driven companies that sell meat-mimicking food to affluent consumers mainly use high moisture extrusion.

Extruded structured plant protein fibers and chunks will increasingly cut into lean meat formulations to either enhance or replace significant amounts of expensive meat sources. Most probably, beef and tuna foods will be the first to develop into "fusion" or hybrid meat products, or even become muscle-free altogether. Beef, salmon, and tuna are expensive muscle foods, whereas, structured plant protein cannot only deliver cost-savings but also contribute to a more efficient and economical use of transitional protein sources. Although chicken is a relatively cheap source of muscle protein, there are dynamics to infuse chicken food with structured plant protein fibers or flakes, such as a wide range of hybrid chicken products, like those appearing on the menu boards at some of the world's largest fast food companies.

Plant Meat Production

The structured protein ingredients can be extruded in many different shapes, sizes, and colors like nuggets, pellets, mince, flakes, and fibers. These products are often formulated using two main components: soy protein and wheat gluten. These two components have covalent disulfide bonds and non-covalent interactions, creating a typical configuration also known as lamella. These lamellas look like fine sheets of material held closely together with hydration fluid in between.

The composition of the extrusion formula largely determines the physical appearance and organoleptic attributes of the structured protein. Both fiber structure and laminar properties (cross-linking and a reformed expandable structure) play important roles and are an integral part of the final product characteristics.

Plant protein ingredients open up in the extrusion barrel to interact with the other formula components such as wheat gluten, potato starch, and plant fibers. Functional plant fibers like those extracted from rice and fruit can be considered support ingredients, and low inclusion levels may be part of the formula.

These (water-insoluble) fibers typically act as a "dispersing phase" somewhat interrupting the nucleation of the melt, and create kind of a diagonal expansion showing a zigzag pattern. Nucleation (aggregation/sticking together) is often found to be sensitive to impurities in the thermodynamic phase of the formula system.

Modifying the Structure

Gluten can be considered a main ingredient for creating lamination of the extruded structured plant protein while soy or pea protein supports the creation of the longitudinal formation of the fibers that mimic cooked meat fibrosity and appearance. Changing the wheat and soy or pea protein ratio can modify the structure of a textured rehydrated plant protein particle. This is especially important to create elasticity and stress relaxation properties, duplicating the structure of muscle and thus closely mimicking cooked meat.

Especially the breaking of the chemical bond in the proteins – disulfide bonds – is essential for creating the protein molecules to realign and linking into longer chains, a process that is very similar to polymerization. The reassembling of the disulfide bonds causes the much sought-after properties to resemble meat. The conditioned dough has a typical processing temperature of 120°C-130°C and finally reaches the die mounted at the end of the long barrel. The simultaneous shearing and cooling in the end-compartment boost lamination and cross-linking. Exactly at the point of the pass-through at the die, the product is cut and shaped.

The combination of added moisture, heat, shear, and pressure in the extruder

› Secondary Support: Other Ingredients to Adopt

Besides the important role of soy protein and wheat gluten, there are a few secondary-support functional ingredients used to improve not only organoleptic quality but also water-holding or water retention. For the latter, stabilized rice bran or rice fiber can be used at an inclusion level of up to 2% to improve the speed of hydration and water retention.

Extruded structured meat analog particles still have an overhang of distinct soy, pea or wheat taste and flavor. The freshly extruded granules or chunks can only be seen as an intermediate product that still needs flavoring through marinade diffusion. Depending on the specific properties of the structured meat analog fibers, chunks, or flakes, the water hydration ranges from 2 to 4 parts. These levels of hydration are typical and analytically provide the same protein values as lean meat. With the use of typical chicken or beef flavors, certain amino acids – the key component of sodium glutamate – can be used to create the much-heralded umami flavor, one of only five the tongue can perceive. The marinating is usually done in large stainless vacuum tumblers that allow flavors such as hydrolyzed plant proteins, yeast extracts, and seasoning/spices diffuse into the structured plant protein membranes.

To simulate cooked beef color, both caramel and malt can be used as a component of the plant meat. New technologies have been developed to include stable heat and color forms of hydrolyzed protein flavors.

The inclusion level of these natural flavors is less than 1.0 percent and allows by-passing of flavor addition and diffusion when the final product is assembled in the processing plant. Also noteworthy is the addition of minute amounts of titanium dioxide which is often used to camouflage the grey color of the soy protein into something more appealing in order to create the typical cooked chicken breast look.▼

barrel creates gelatinization of the starch and denaturation of the plant proteins. This is a viscoelastic mass that flows and allows alignment as well as cross-linking, then immediately expands into the required shape and structure when finally escaping the die. A number of secondary support ingredients are discussed in the box on page 38.

High Moisture Extrusion

High moisture extrusion (HME) can be described as a system in which a blend of plant proteins, starches and processing aids are moved into a pre-conditioner where water and some oil are added. This mixture is then moved into co-rotating and intermeshing steel augers, while specific heat, pressure, and shear conditions alter the protein structure. This mechanical process very quickly creates a dough-like paste, while pushing it forward into the long barrel for transformation into a laminated and fibrous meat-like product.

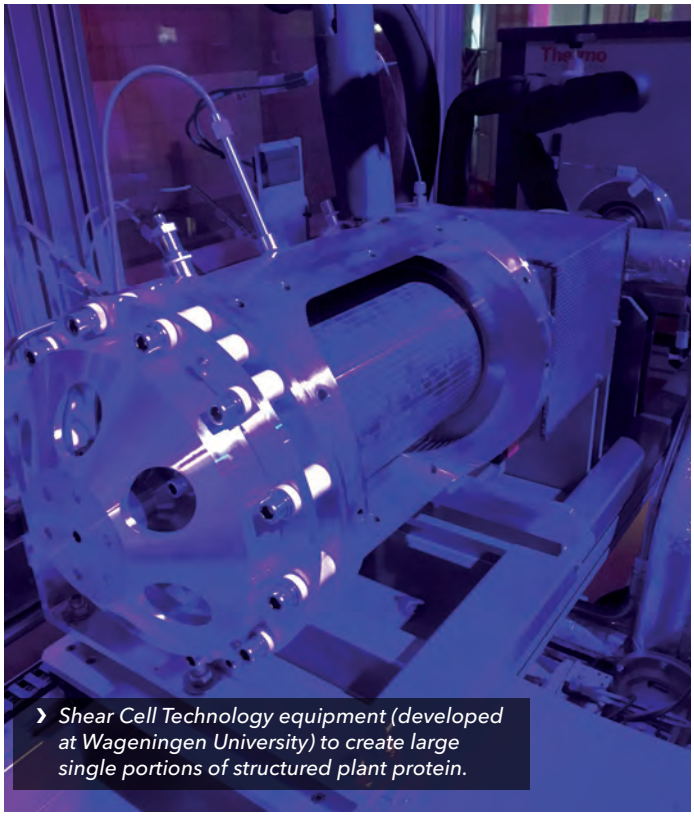
Innovative extrusion technology allows for the conversion of plant protein to animal protein characteristics i.e. meat properties. It requires quite a bit of knowledge of protein interaction and extrusion expertise to perfectly match the organoleptic properties of cooked meat.

High moisture extrusion technology generates products that have the taste and mouthfeel of the genuine muscle meat, without the need for rehydration. These types of plant meat foods are perfectly suitable for "heat & eat" consumption.

The product specifications of high moisture meat analog products are typically similar to harvested meat: 70-75 percent water, 15-20 percent protein, and 2-5 percent fat.

Shear Cell Technology

Another method to fully utilize the potential of plant protein is so-called "shear cell technology," which allows the formation of structured "plant meat" analogs with significantly larger dimensions. Originally, shear cell technology was developed for the structuring of milk protein foods and is now being readied for plant protein meat substitutes showing a whole muscle appearance. In particular, the shear cell technology demonstrates interesting opportunities to ultimately replace the current standard of extrusion methods. In theory, the configuration of the cylindrical shear cell appears to be the most suitable for scaling-up to industry requirements and as such to become a contender to replace the traditional extrusion equipment.



› *Shear Cell Technology equipment (developed at Wageningen University) to create large single portions of structured plant protein.*

Shear cell technology is capable of creating fibrous structures similar to meat, including the flexibility to regulate the length of the fibers. These fibrous structures contain a clear hierarchy, which is typical for meat. In theory, both plant and animal proteins can be used, either singularly or blended. For obvious reasons, researchers focus on using various plant proteins as a platform to build on. Cylindrical shear cell technology might push the boundaries by improving product textural properties while using up to an estimated 30 percent less energy. Also, it is estimated that total investment costs are also considerably lower. The latter is something that still needs validation because a full-scale model with comparative output still needs to be built and proven. If the shear cell technology can maintain momentum and find a launching partner, the system could be in full production by 2018. Most, if not all, of the shear cell technology has been done at Wageningen University, Department of Food Process Engineering in the Netherlands.

Still Room for Improvement

Despite all the progress, meat analog foods can still be further improved. One of the most significant drawbacks is that most of these structured plant proteins are sold frozen to consumers or food service. Once the product is marinated and frozen, permeation of further flavor refinement is difficult to achieve.

Also, the freeze/thaw cycle negatively affects the textural properties suffer – most notably, its chewiness and graininess flaws.

To immediately reduce meat consumption, the way forward should be to choose a path in which lean meat is blended or infused with structured plant protein extrudates that ingeniously mimic beef, chicken or tuna. Infusing hydrated structured plant protein ingredients or particles with a portion of lean meat. World-famous franchised restaurants have successfully introduced this concept by using this technology to offer affordable chicken patties, burgers, breakfast links, pizza toppings, and spaghetti meat sauce, while maintaining nutritional value.

Brain Reference

The principle of true meat analog made by innovative structured plant protein products is based on a psychological concept known as homophily – the notion of linking similar reference foods that are rooted deep in the memory of the brain. These structured plant protein products not only enjoy consumer acceptance but also contribute to making food more sustainable and ecologically friendly. Manufacturers who use these extrusion technologies for structured plant proteins are constantly testing and tweaking its product features, paying close attention to the consumers' responses.

For now, the downside of high moisture extrusion is its rather high consumer prices. Retail prices are typically higher than their meat equivalent. Only affluent consumers can afford these high prices. Eventually, prices need to come down to be competitive with animal protein.

The future starts today and an entirely new plant protein platform will emerge, changing the landscape forever.▼

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