Whitepaper

Paradigm shift for the meat industry – the role of alternative proteins.

Innovations for a **better world.**

BÜHLER

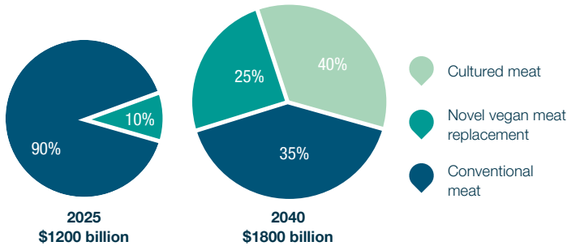
Paradigm shift for the meat industry.
The role of alternative proteins.

The global food industry is facing a massive challenge of feeding a population of 10 billion people, a number we are expected to reach by 2050.

Feeding a population of 10 billion people.

Our food supply systems are very complex, comprising of multiple steps, from the farm to storage, transport, processing, retail and ending eventually at the plate of the consumer. Our food system is quite a burden on the planet, taking up 70% of the world's available fresh water for agriculture, in addition to a tremendous amount of energy, and contributing to nearly a quarter of global green-house gas emissions. Despite all of this, one-third of all produced food is eventually wasted.

With population growth comes an expected change in demographics. A shift towards more urban lifestyles, with the majority of the world eventually living in cities, suggests an increase in purchasing power. With the growing awareness among consumers of balanced and protein-rich diets, there is a tendency towards putting as much protein on the plate as possible.

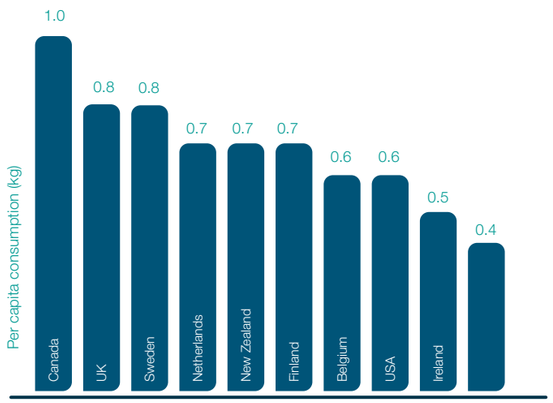


Projected growth of alternative protein solutions. Source: ATKearney

10 billion people
to feed by 2050

250 million metric tons of
additional protein a year

1/4 of food produced for
humans goes to waste



Total consumption of meat substitutes 2019 in Western Europe, North America, Australasia

Source: Euromonitor International

The increasing demand for meat and animal-based protein puts pressure on existing protein sources such as soy and fish meal, and is expected to add pressure on land to produce more feed and protein for animals.

Challenges in livestock farming.

Civilization was built on the foundations of agriculture and animal farming. Society as we know it today would not exist without the agricultural advancements that have sustained many generations of food security for most of us. As the global population continues to grow, the pressure we put on the planet's resources to feed this population increases. While animal agriculture accounts for 3/4 of the world's land used for food production, it only provides 18% of the world's calories. Today's animal farming is reaching an ultimate peak with 70 billion land animals every year used for food. The environmental impacts (water usage, CO2 and greenhouse gas emissions, biodiversity losses) and caused zoonotic diseases like swine flu lead to a shift in consumers perceptions. In order to feed 10 billion people by 2050 sustainably, we need to balance plant-based protein and animal-based protein consumption. As meat is so dominant in today's nutrition, the most effective transition can be achieved by transforming plant proteins directly into meat-like products, which have similar taste and texture to meat but are plant based.

Alternative sources of proteins are needed.

Today, consumers are compelled to reconsider their food choices and look for alternative sources of proteins. Moreover, they are exploring diversity of foods and expect more choice in the products available on the market. Researchers around the world are therefore looking for novel proteins sources which could be valorized for human consumption. In this race, plant-based proteins top the charts as they are becoming increasingly popular among consumers. Through twin-screw extrusion technology, it is possible to use plant-based protein sources to create products that mimic animal-based meat such as chicken chunks, burgers, pulled pork, tuna, etc. Pioneering food producers have had huge success with recent plant-based meat market launches and the enthusiasm of consumers in buying such products is in turn fueling the plant-based revolution.

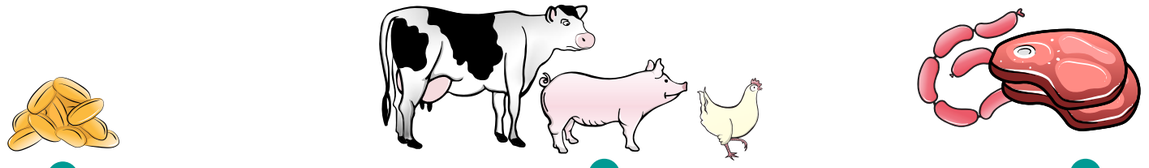
First meat producers are launching their own plant-based meat brands

It is expected that the global protein market share will be dominated by alternative proteins, including both plant-based and cultured meat, by 2040, leading to a considerable reduction in traditional meat products. This has intrigued many companies from the traditional meat and dairy industries, encouraging them to diversify their portfolios and cater to the needs of the market. According to the 2019 'US State of the Industry Report' by the Good Food Institute (GFI), there was a 31% increase in the retail sales of plant-based meat substitutes, compared to only 5% for actual meat products, between the years 2017 and 2019. This explains the entry of food giants like Nestlé, PepsiCo and Kraft Heinz into this segment of plant-based meat substitutes.

Additionally, many traditional meat producers such as Tyson and Hormel have launched their own plant-based meat brands such as 'Raised & Rooted' and 'Happy Little Plants' respectively.

The traditional meat industry can provide expertise from the processing of animal meat to create familiar cuts, shapes and forms out of plant-based meat substitutes, which can further improve the meat mimicking process. Additionally, the same equipment can be used to produce different product categories with diversified textures by simply altering the extrusion settings. This is typically not the case with handling traditional meat products. For example, a company that has expertise in producing plant-based beef can now enter the plant-based seafood market, just by optimizing the process. Hence, it is a huge opportunity for traditional meat companies to diversify their product portfolios.

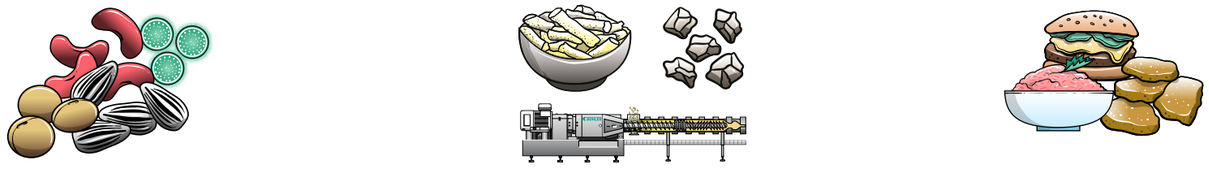
Traditional meat production



Raw material handling → Livestock feeding → End Products

Traditional meat production begins with the handling and processing of raw materials used as feed for livestock. After the animals have grown sufficiently, they are transformed into final meat products for the end consumer.

Plant-based protein production



Raw material handling → Extrusion process → Plant-based meat substitutes

Plant–based meat production is similar to traditional meat production in that it also starts with the processing of raw materials such as grains or pulses. The difference in plant-based meat is that the animal is removed from the supply chain. Raw materials are directly and efficiently transformed into meat–like products through extrusion technology.

The role of technology in mimicking meat:

Despite the existing concerns in the food system, and especially in the protein value chain, it is a challenge for consumers to fully shift to plant-based diets. People love the sensory experience involved in eating meat, not only from the flavour but also from the texture of the product. The biting quality and the chewiness that is provided by a meat product is missing in traditional plant-based meat substitutes such as tofu and tempeh.

With the advent of high moisture extrusion in food technology, it is now possible to mimic meat products more closely. Plant proteins in their raw state are typically globular in structure. As they are processed inside the extruder, the shear forces and the increase in temperature lead to a denaturing of these plant-proteins, allowing them to be re-aligned into long fibers. The cooling die is a vital attachment at the extruder die. As the restructured protein melt flows through the cooling die, the phase separation results in a fibrous and layered structure, which is then cooled to a solid product exiting the cooling die. This meat substitute, typically a rectangular slab due to current cooling die designs, can then be further processed to create diverse products such as minced meat, pulled pork, burger patties and chicken chunks.

Fibrous structures with dry extrusion

In addition to high moisture extrusion, there have been considerable improvements in the dry extrusion process to produce meat substitutes. Dry extrusion uses plant-based protein sources which can be turned into fibrous structures using shear and heat, similar to high moisture extrusion. However, in this process, the temperature profile of the extruder is higher which results in flash evaporation of moisture as the product exits the extruder die. The product after the extruder is then cut into various shapes using a continuous cutter and dried to reach a stable shelf-life condition.

Popular and futuristic proteins sources for meat substitutes

Current popular plant-based meat substitutes in the market are produced from soy protein or pea protein-based recipes. As an example for high moisture extrusion, one can formulate basic products by mixing 33% soy protein concentrate with 66% water, or 45% pea protein isolate with 55% water in the recipe. The extrusion conditions also differ depending on the recipe. Typical temperatures would reach up to 145-150°C when extruding soy protein concentrate, while for pea protein isolates, temperatures in the range of 130-145°C are used. The configuration of the screw elements are also adjusted depending on the protein sources in order to provide the necessary amount of shear force inside the extruder. These process parameters are optimized with experience and scientific understanding.

Other protein sources gaining popularity more recently are chickpea, lentil, potato, fava bean, and mycoprotein, which all have great nutritional properties and can be used to produce meat-like structures. With the furthering of fermentation technology, single-celled proteins such as algae, yeast, and bacteria will become more important in the near future.

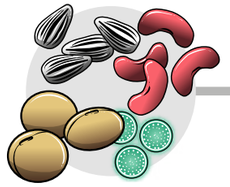
In conclusion, scientists and industries around the world are continuously engaged in exploring the nutritional and functional aspects of alternative protein sources in order to make our protein value chain more efficient. Meat substitutes present a great opportunity for sustainability in our food systems and Bühler as a technology solution provider is committed to playing a key role in this movement.

Find your perfect solution

Both high moisture and dry extrusion have their own advantages and can be used to produce meat substitutes with specific characteristics. Bühler, as a complete solution provider for the meat substitute value chain, is heavily engaged in innovation on this topic. Specializing in both dry and high moisture extrusion, Bühler enables its customers to find solutions with their customized recipes in order to achieve the desirable layered and fibrous texture, like that of meat. Bühler's application centers located in Minneapolis (USA), Uzwil (Switzerland), Singapore and Wuxi (China) enable customers to carry out trials for recipe and process optimization with the expert support of Bühler's technology team. In order to cater to the growing demand, plant-based meat producers need to increase the throughput of their processes. Bühler's unique solution for 500 kg/h and 1000 kg/h throughput from the cooling die makes it the world leader in state-of-the art technological solution provider. Apart from the extruders and the cooling dies, Bühler also provides solution for pre-processing of the material using pre-conditioners. These pre-conditioners can provide an additional residence time for the recipe which might be required to activate certain physico-chemical reactions, in order to improve the functionality of the recipe components.

The technological advancement in the meat substitute segment has prompted numerous start-ups to launch in this market. According to the GFI report quoted above, there was an investment of 457 million USD in 2019 alone in the plant-based sector. Hence, the growing eco-system in this segment is an indicator of the growing interest from consumers for such products.

Plant-based protein production.
Process and products.



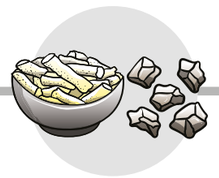
Raw Material and processing

Process
The raw materials such as soybeans, pulses, or oilseeds are processed into protein isolates (wet process) or protein concentrates (dry process). Both can then be used as the main protein source for the production of alternative meat products.

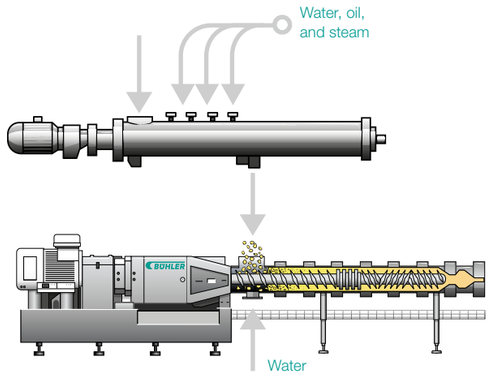
Protein concentrate or isolate and oilseeds
Protein concentrates are derived from the mechanical separation of flour, using the density difference from the starch and protein fraction. Protein isolates are further separated with a wet process, where the proteins are dissolved. These products are typically higher in protein content, with less taste from the origin raw material. Oilseeds expeller cake can be upcycled after the oil pressing and used as a high-protein ingredient.

Fiber-rich fraction and flours
Fibers are a healthy ingredient that is naturally available in the raw material. With added fiber, the product texture becomes stronger, and the protein network is more stably interlinked. There is a multitude of fibers available, like pea, citrus, or apple fibers. Flours can also be used as a minor or major ingredient to adjust the product behavior.

Fortification and flavoring
Ideally, meat substitutes contain all of the positive ingredients of meat, without too much fat and cholesterol. Important vitamins, such as B12, and minerals, such as iron, fortify the textured product. In some cases, natural flavors are added as well to imitate the taste of real meat in the product.



Preconditioning and extrusion



Extruder
The versatile twin-screw extrusion technology transfers the plant protein mixture into a fibrous, meat-like textured product. A dough is created with the mixture of water and proteins. With the application of mechanical shear force and temperature, proteins are denaturated and fibrous structures are generated.

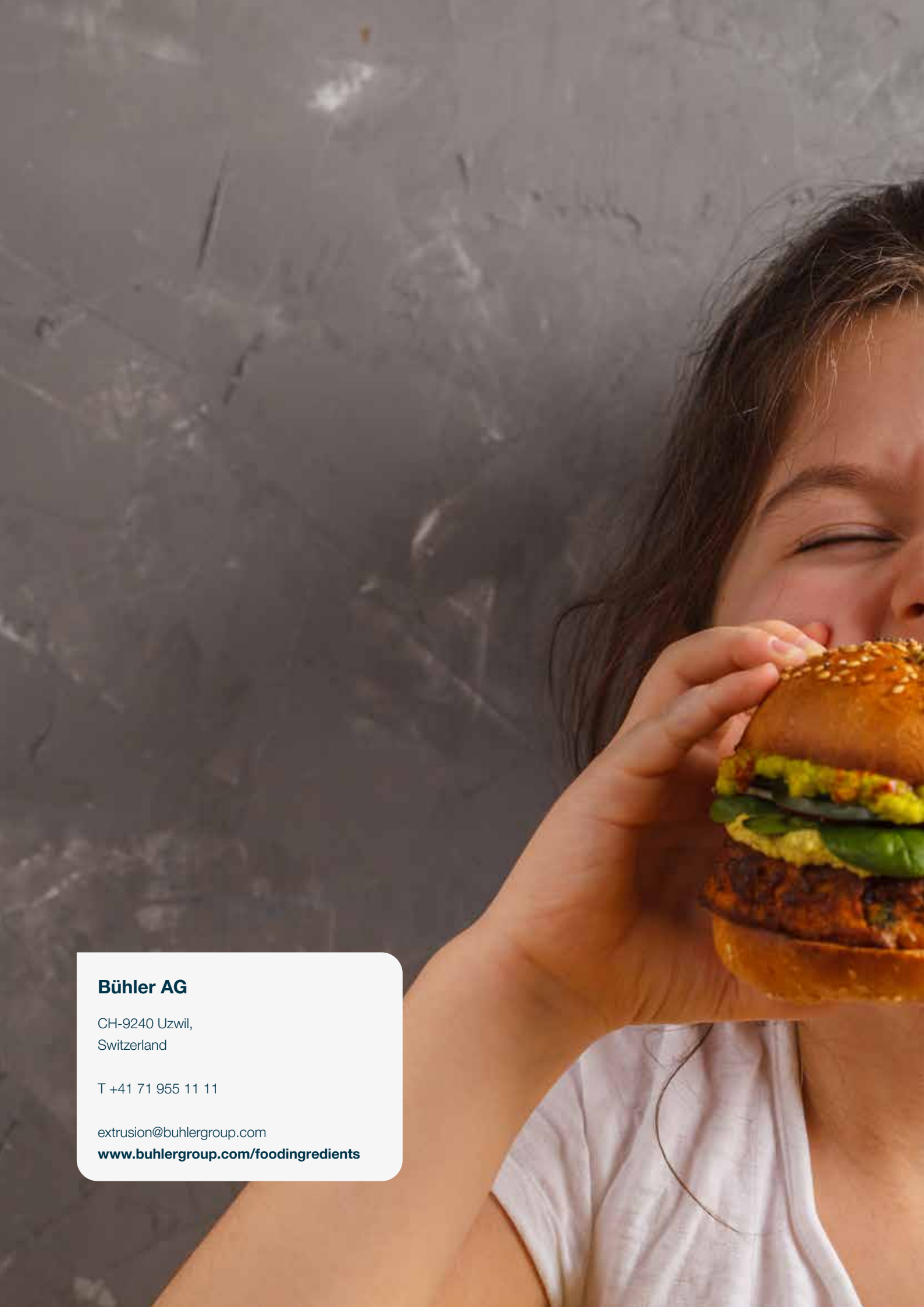
Cooling die
High-capacity cooling die for wet textured products.

End Products

Dry textrudate process
The fibrous protein structures go through further processing of cutting and drying to produce dry textrudates. Rehydaration and flavoring improve the taste, while gluing and forming creates the correct texture. The minced meat substitue can be used as a replacement in burgers and other such dishes.

Wet textrudate process
A high capacity cooling die is used to cool extruded proteins. With further processes of cutting, forming and freezing, the meat substitute can be used for plant-based pulled chicken and nuggets.

Milk analogues process
After extrusion, proteins can also be processed into oat milk or other milk substitutes. The proteins are cut, dried, ground and finally dissolved in water to produce dairy substitutes. Adding yogurt bacteria and fermentation further increases scope to produce plant-based yogurt.



Bühler AG

CH-9240 Uzwil,
Switzerland

T +41 71 955 11 11

extrusion@buhlergroup.com
www.buhlergroup.com/foodingredients