amixon
MIXING TECHNOLOGY

– amixon® whitepaper –

Is your production line ready for the plant-based future of food?

amixon® mixers and plant-based new product development

The key role of mixing equipment in manufacturing vegan meat substitutes

Meeting the needs of meat-free manufacturing

As demand for healthy, ethical, and tasty alternatives to animal agriculture continues to grow, the food industry landscape is seeing dramatic changes. From vegan start-ups to some of the most established names in meat processing, food industry businesses of every ilk are investing in the production of plant-based foods resembling meat, dairy, and eggs.

But satisfying this rising demand for plant-based products is not without its challenges. After all, the fastest growing market for these foods are not strict vegans or even vegetarians, but omnivores looking to reduce their consumption of animal products. Appealing to this flexitarian demographic means creating plant-based foods that not only look, taste, and cook like animal-derived products, but that are also healthy and affordable to boot. Achieving this requires sizeable investments in both new product development and processing equipment.

This whitepaper from amixon GmbH aims to provide insights into the manufacturing challenges faced by producers of plant-based foods and the role of mixing equipment in meeting the demands of this quickly growing market sector. Industrial mixers are a crucial piece of equipment in the production of plant-based foods, helping manufacturers develop new product formulations, ensure hygiene, and scale their processes to peak efficiency and profitability.

ABOUT AMIXON

Industrial mixing technology made in Germany

For nearly 40 years, amixon® has been a market leader in the manufacture of sophisticated, high-precision mixing equipment for diverse processing needs. Made in Germany from food grade materials, outfitted with hygienically optimized proprietary technology, and customized to the exact specifications of your products, amixon® mixers offer state-of-the-art bulk material processing solutions for industrial food manufacturing.

Content

amixon® Vertical Twin-Shaft Mixer HM

1 The plant-based future of the food industry

Recent events have made it increasingly clear that the current state of industrialized animal agriculture is unsustainable. A growing conscientiousness about the environmental impacts, biosafety risks, dangerous workplace conditions, and animal welfare issues associated with animal protein production is informing meaningful changes in consumer eating habits.

1.1 The rise of the flexitarians

Plant-based alternatives to animal protein have existed for many years, but until recently, they were mostly developed for niche vegan and vegetarian consumer bases. While the number of vegans and vegetarians has certainly multiplied over the last decade, the most significant changes to the food industry landscape are being driven by flexitarians: a rapidly growing population of consumers in industrialized nations who seek to reduce but not eliminate animal products from their diets.

According to a 2019 survey of consumers across four continents, 27 percent of respondents agreed with the statement: "I am trying to cut down on my meat intake." These consumers cited a wide range of reasons for this decision, from health, to environmental concerns, to animal welfare (cf. Euromonitor 2019).

1 in 3

US households had at least one member voluntarily following a vegan, vegetarian, pescatarian, or flexitarian diet in 2019.
(cf. FMI 2019)

19.2%

was the increase in US sales of plant-based meat alternatives between 2018 and 2019
(cf. FMI 2019)

240%

more products with vegan labels were available at German grocery stores in 2018 compared to 2013
(cf. Mintel 2018)

16%

of new food products launched in the UK during 2018 were vegan
(cf. Deloitte 2019)

1.2 Plant-based is more than a trend

The purchasing power of concerned consumers has certainly been a driving force in compelling food industry businesses to expand the production of plant-based foods. However, there are other economic imperatives fueling the growth of non-animal derived products as well.

Experts warn the current model of animal agriculture requires far too many resources on a per calorie basis in order to feed the growing world population. Rather than clearing land to plant, water, and harvest crops to feed livestock, those same resources could be used to grow crops that would provide between three to five times more calories for humans (cf. GRAIN & IATP 2018). For many food industry businesses, expanding their plant-based product offerings is seen as a way to secure their continued existence in the face of shrinking natural resources.

Furthermore, the COVID-19 pandemic has brought tremendous scrutiny to both the economic vulnerabilities and safety risks associated with factory farming. Between the rampant spread of infection among workers in meat processing plants and supply chain failures, livestock has come to be seen as one of the most precarious commodities in the current economy. Furthermore, meat production and processing is known to harbor biosafety risks, from zoonotic diseases to antibiotic resistance, that could trigger the next global pandemic (cf. FAIRR 2020)

1.3 Investing in animal-free production

Between the growing demand, questions of resource efficiency, and biosafety threats, all signs point to plant-based foods as the future of the food industry. And investors are taking notice.

A number of vegan start-ups have skyrocketed to prominence in recent years, partnering with some of the globe's biggest restaurant brands and becoming household names in their own right. From plant-based burgers that "bleed," to vegan egg-substitutes, to artisan cheeses made without dairy, this is a market sector ripe for innovation. These entrepreneurial companies are receiving financial backing from high-profile angel investors and federal governments alike (cf. Deloitte 2019).

But it isn't just start-ups that are building out the facilities needed to fuel the food industry's plant-based future. Global brands like Danone, Nestle, and Unilever have made moves to acquire smaller plant-based food manufacturing brands as a means of diversifying their own production portfolio (cf. Deloitte 2019).

Even some of the biggest names in meat are seizing this moment to expand into animal-free products. 15 of the world's 60 largest animal protein producers have already invested in their own means of producing plant-based proteins, a move that their investors see as necessary to fuel growth and profitability, reduce risks of zoonotic and antibiotic-resistant diseases, and improve the corporation's ability to remain competitive despite shrinking resources (cf. FAIRR 2020).

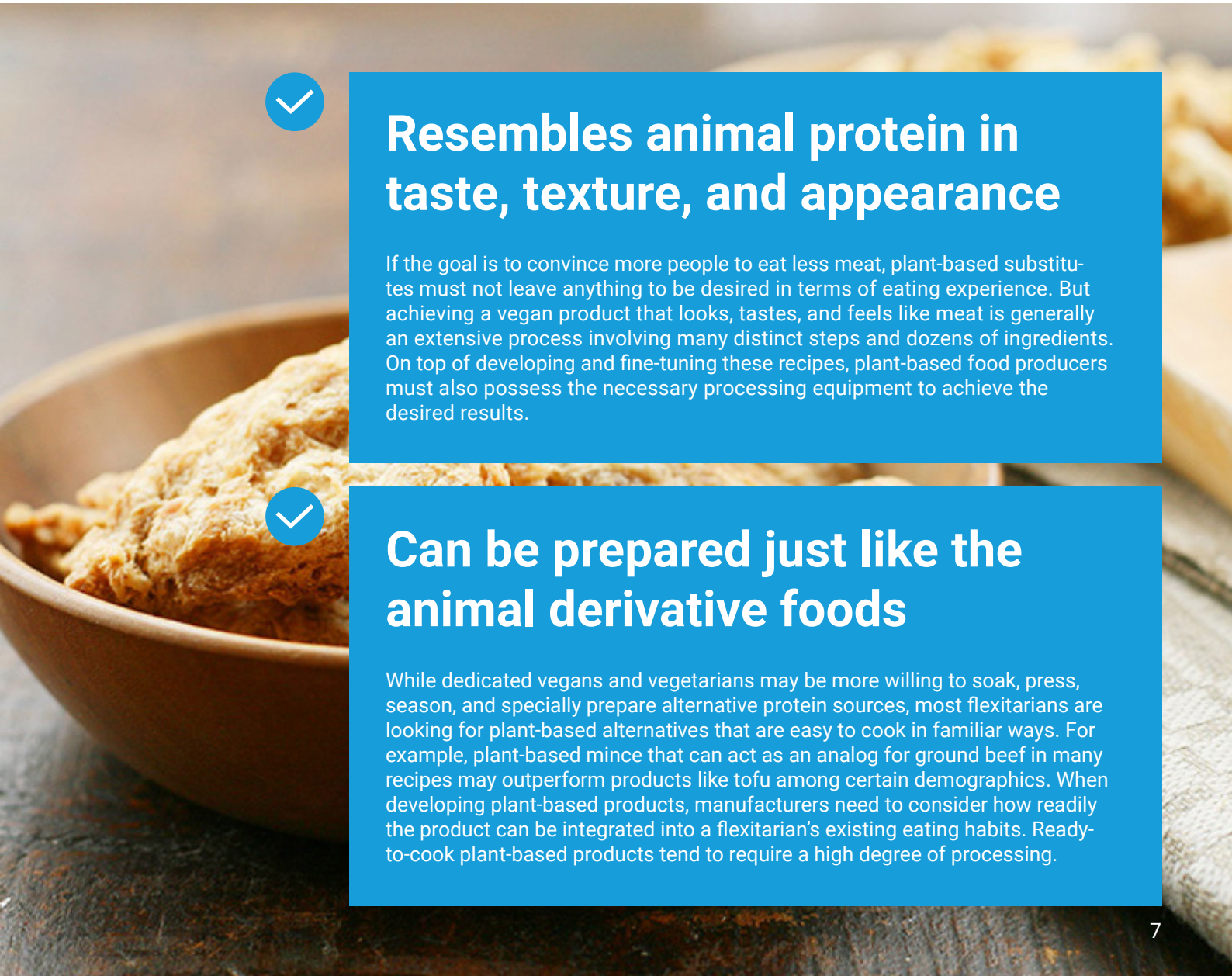
From plant-based burgers that bleed, to vegan egg-substitutes, to artisan cheeses made without dairy, this is a market sector ripe for innovation.

2 The challenges of producing meat-free meat

Though the production of plant-based substitutes may have a number of economic advantages over animal proteins, producers and processors looking to expand in this burgeoning market should be prepared to contend with challenges. Significant resources must be invested in new product development and processing trials in order to create products that adhere to varying definitions of the descriptor “vegan,” meet consumer expectations, and can be scaled to a profitable volume.

2.1 Appealing to a flexitarian consumer base

Consumers looking to reduce but not eliminate animal products from their diets are often on the lookout for convenient vegan alternatives to the animal-derivative products they already consume. In order to fill this role, plant-based substitutes should ideally check each of the following boxes:

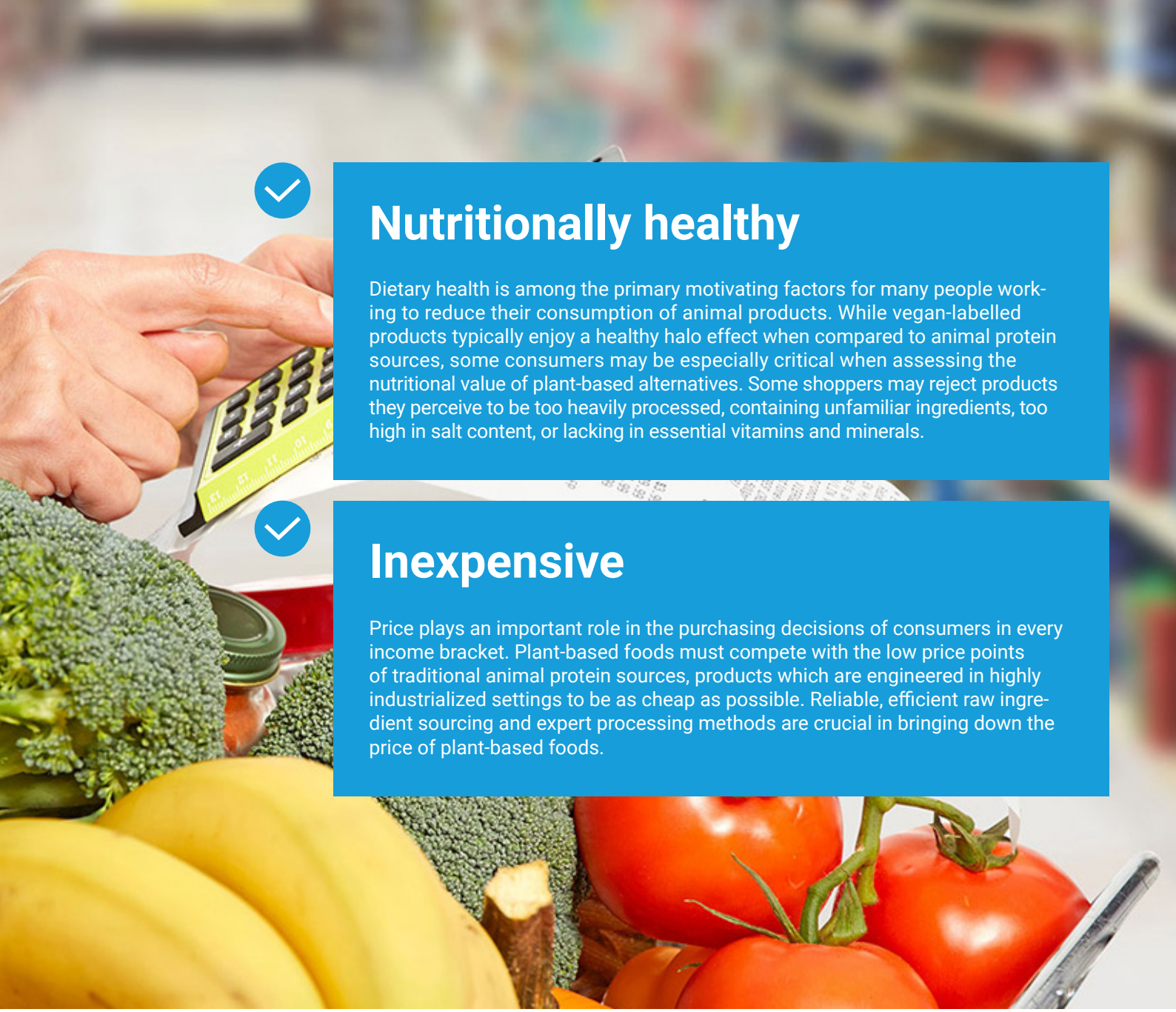


Resembles animal protein in taste, texture, and appearance

If the goal is to convince more people to eat less meat, plant-based substitutes must not leave anything to be desired in terms of eating experience. But achieving a vegan product that looks, tastes, and feels like meat is generally an extensive process involving many distinct steps and dozens of ingredients. On top of developing and fine-tuning these recipes, plant-based food producers must also possess the necessary processing equipment to achieve the desired results.

Can be prepared just like the animal derivative foods

While dedicated vegans and vegetarians may be more willing to soak, press, season, and specially prepare alternative protein sources, most flexitarians are looking for plant-based alternatives that are easy to cook in familiar ways. For example, plant-based mince that can act as an analog for ground beef in many recipes may outperform products like tofu among certain demographics. When developing plant-based products, manufacturers need to consider how readily the product can be integrated into a flexitarian’s existing eating habits. Ready-to-cook plant-based products tend to require a high degree of processing.



Nutritionally healthy

Dietary health is among the primary motivating factors for many people working to reduce their consumption of animal products. While vegan-labelled products typically enjoy a healthy halo effect when compared to animal protein sources, some consumers may be especially critical when assessing the nutritional value of plant-based alternatives. Some shoppers may reject products they perceive to be too heavily processed, containing unfamiliar ingredients, too high in salt content, or lacking in essential vitamins and minerals.

Inexpensive

Price plays an important role in the purchasing decisions of consumers in every income bracket. Plant-based foods must compete with the low price points of traditional animal protein sources, products which are engineered in highly industrialized settings to be as cheap as possible. Reliable, efficient raw ingredient sourcing and expert processing methods are crucial in bringing down the price of plant-based foods.

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2.2 Scaling production profitably

The plant-based food industry is not lacking for impassioned innovators or consumer demand. The key obstacles to success in this market lie instead with ramping up production to meet the moment.

Plant-based food industry leaders on the challenges of scaling production:

> **"We've all got great products and there's more innovation going on. But it's scales. There need to be massive factories for where this market movement is going."**
>
> – Heather Mills, founder of VBites (quoted in Ridler 2019)

> **"It was a lot harder than I thought. It cost a lot more money than I thought. It ended up taking well over four years to find [a plant] that scrambled and then another two years to figure out a way to scale it up to put it in the supermarket."**
>
> – Josh Tetrick, founder of JUST Egg (quoted in Watrous 2020)

> **"If we're not careful, we'll have a strained supply chain where we won't be able to deliver."**
>
> – Laith Wahbi, Global Technical Director of Firmenreich's Savoury Business Unit (quoted in Ridler 2019)

As a long-standing industry, food processors in animal agriculture already have the infrastructure to source, transport, process, and deliver a tremendous volume of meat, egg, and dairy products. As relative new-comers, many producers of plant-based foods are struggling to efficiently source diverse ingredients and to process them at scale.

Generally speaking, vegan food producers have the benefit that there are simply more plant-based than animal-derived protein sources to choose from. While the diversity of plant-based proteins can in theory make the vegan supply chain more resilient to sudden and sweeping disruptions, currently there are not many plant-based protein sources with a global production volume and price point that can rival the massive machine of factory farming.

In the short-term, it can be tempting for plant-based food producers to rely on pea and soy, two versatile protein sources already produced at a massive scale, rather than invest in building out a secure and diversified supply chain composed of many plants (cf. Ridler 2019). But further diversification is necessary for the plant-based food industry to achieve peak environmental and economic sustainability for the long-term (cf. Askew 2019).

But beyond investment in a broader network of smaller, more varied supply chains, plant-based food producers must also build out their manufacturing processes. Plant-based recipes require both extensive fine-tuning and high-performance equipment in order to replicate animal-products in terms of taste, texture, appearance, and cooking function. And because different raw materials require different treatments to achieve a uniform end result, the production process for plant-based foods can vary significantly from recipe to recipe.

amixon® Vertical Cone-Mixer AM

2.3 A lack of standardized definitions

But once a plant-based food producer has gotten their supply chain and processing facilities up and running, they must still contend with the fact that this new and rapidly growing industry is bound to undergo serious regulatory changes in the coming years.

To date, the world's major markets lack any legally binding definitions or unified standards for terms like "vegetarian," "vegan," and "plant-based." As such, there are still many open questions about what qualifies as a "vegan" product. Does the presence of trace-amounts of animal-derived ingredients invalidate any vegan claims? Must products carrying vegan claims be prepared in dedicated facilities? And if not, what controls need to be in place to ensure compliance?

A growing number of food producers and processors in the plant-based sector work with international certifying bodies, like V-Label or the Vegan Society, who audit their processes and provide a registered logo for their products. But as of yet, many on-package vegan or vegetarian claims are not subject to the same process qualifications that terms like "organic" or "low fat" are.

This lack of clarity has led to confusion and concern among consumers and advocates. The past few years have seen a number of troubling instances in which vegan-labelled products were proven to be contaminated with ingredients derived from animals (cf. European Vegetarian Union 2019). In addition to the ethical dubiousness of these cases, it also draws attention to the issue that some consumers dangerously assume vegan or vegetarian labels can be used to avoid common food allergens like dairy and eggs (cf. Sage 2019).

The European Union is currently working on developing standardized definitions for these labels. In the meantime, food safety experts recommend that food brands in the plant-based market sector carefully assess the claims they are using and their manufacturing strategy going forward (cf. Sage 2019). Brands that intend to continuing using "vegan" and "plant-based" claims should be prepared to examine every risk factor in their facilities that could invalidate these claims. Especially for brands that currently use mixed facilities, it may soon be necessary to invest in dedicated factories and equipment for their plant-based food products.

3 The role of mixers in plant-based food production

High-performance mixing equipment is crucial for both the production and the recipe development of many types of plant-based protein sources. Mixers used in plant-based food production need to be effective on the one hand, but also flexible and highly hygienic on the other. Choosing the right mixer or series of mixers for vegan food production facilities will not only ensure that products are safe and high-quality, but can also help food producers develop innovative new plant-based recipes.

Mixing is among the most decisive steps in the entire production process in terms of its impact on the resulting product quality, especially for plant-based meat substitutes.

3.1 Mixing and Product quality

Generally speaking, the production of plant-based meat substitutes involves many processing stages. Mixing is among the most decisive steps in the entire production process in terms of its impact on the resulting product quality, especially for plant-based meat substitutes.

Most meat substitutes are produced by wetting and then extruding a dry protein mixture. This base mix can often contain over 30 different components, with each ingredient playing a distinct function in the recipe: spices, flavor enhancers, preservatives, binding agents, vitamins and minerals, thickening agents, texturizers, emulsifiers, lipids, aromas, leavening agents, coloring agents, and stabilizers, to name a few. If any of these ingredients are not adequately homogenized into the mixture, the resulting products could display significant quality issues.

But achieving a homogenous mixture is in and of itself challenging. The assorted mixing ingredients used in plant-based food production have physical properties that vary hugely in terms of moisture, density, particle size, rheology, and stability. A mixing process involving too much shear and/or agitation can shatter delicate particle structures that must be preserved for the product to adequately coagulate and attain a fibrous, meaty texture.

amixon® mixers are specially designed for challenging recipes like these. For example, the twin-shaft mixer HM from amixon® offers a particularly gentle yet effective solution for high-volume applications in plant-based food production.

The HM mixer vessel consists of two cylinders that have been fused together. Each cylinder houses a spiral mixing tool with a slight incline of 30°. The tilted helical blades gather powdery contents at the periphery of the vessel and convey them upwards. Once the powders have reached the top, they flow back down along the mixing shafts.

This movement generates a three-dimensional current in the spaces between the upward flow on the periphery and the downward flow in the center. The actual mixing, i.e. particles changing places with one another, happens between these two macro flows. This deadspace-free mixing operation is especially gentle and energy efficient, able to produce technically ideal mixing qualities in as few as 20 to 90 revolutions.

3.2 Flexible processes and new product development

As the plant-based market has expanded, vegetarian, vegan, and flexitarian consumers have come to expect tremendous variety in the plant-based protein options available to them. And in their pursuit to find their favorite meat, egg, and dairy substitutes, many consumers are eager to try out new plant-based product formulations. Take, for instance, the tremendous array of plant-based milks on the market today, with formulas based on a wide variety of nuts, seeds, and grains.

Bringing such a diversity of plant-based foods to market demands that producers have flexible equipment. amixon® mixers are exemplary in this regard, able to accommodate highly variable raw materials and production conditions:

Wide range of processing functions

Many amixon® mixer models can perform a range of different tasks, such as drying, reacting, coating, homogenizing, dispersing, conditioning, deagglomerating, and agglomerating.

Precisely adjustable settings

From residence time to mixing velocity to atmospheric pressure, just about every aspect of the mixing process can be calibrated according to the exact requirements of the task at hand. For this reason, amixon® mixer models can accommodate materials with highly variable characteristics, from fine dry powders to viscous pastes.

Variable filling levels

amixon® mixers can achieve uniformly excellent mixing results at filling levels as low as 10 percent, giving producers the flexibility to produce different volumes of different products using the same mixing equipment.

The flexibility offered by an amixon® mixer is highly valuable from the perspective of new product development, giving plant-based food producers the chance to easily test small batches of experimental recipes. And for facilities that produce any number of products with different recipes, a single amixon® mixer can effectively process a range of varying formulations.

amixon® Continuous Mixer AMK

3.3 Continuous Production of plant-based meat substitutes

Automated continuous production processes are generally favored by plant-based food producers operating at high volumes for their cost-effectiveness. However, a completely continuous process is difficult to implement for facilities that produce a variety of meat substitute products made from different base recipes. Depending on the frequency of recipe changes and the number of individual components needing to be mixed, continuous mixing can become highly complex to orchestrate.

The difficulty lies in the fact that different powders can display tremendously different behaviors when dispensed, making it nearly impossible to automate this processing step and still achieve consistent results from recipe to recipe. For this reason, it often makes the most sense to use batch production methods to prepare interim mixtures of bulk protein powders.

For this unique processing challenge, amixon® offers a state-of-the-art continuous mixing system which also doubles as a precision batch mixer: the AMK continuous mixer.

The AMK is a vertically mounted spiral mixer with excellent mixing quality. The AMK can be used both as a batch mixer and as a continuous mixer. It can homogenize complex premixes with over 30 individual components in batches and achieves ideal mixing qualities. This premix is transferred into a continuously operating dosing unit, which in turn feeds the AMK. The premix can then be distributed micro-fine into large basic masses such as starch, milk or whey powder, cheese powder, cellulose powder, salt, or even moist masses. The AMK empties to almost 100% and can be cleaned very quickly, dry, moist, or even wet. Campaign changes can be carried out quickly.

3.4 Hygiene and concernsof contamination

It goes without saying that food safety is the top priority in any food production or processing facility. But as we have seen, the production of plant-based foods involves additional consideration in terms of preventing contamination.

Any facility that manufactures plant-based foods alongside animal-derived products can only reliably prevent contamination by means of thorough wet-cleaning protocols. amixon® mixers are designed to simplify the wet-cleaning process in a number of ways:

Hygienic design

amixon® mixing vessels and blades are made from food grade stainless steel with a smooth, sanitary finish to minimize the build-up of material residues. The mixing shaft is driven and mounted only from the top, out of contact with the mixing goods. The inspection doors are produced using the CleverCut® method, during which an O-ring is inserted into the groove, creating a gas-tight, dust-free seal that is both close to the product and free of deadspace.

Innovative technology for complete discharging

amixon® mixers with conical floors can quickly discharge flowable bulk materials without segregation. But ComDisc® technology makes it possible to achieve up to 99.997% discharge even in flat-bottomed mixers. Installed at the bottom of the mixing shaft, this flexible mechanism floats through the product during the mixing process and lowers to the vessel floor upon discharging. There, it sweeps the bottom of the mixer in a radial fashion, pushing the mixing goods towards the discharge outlet. The result is less product loss and a cleaner mixer interior.

Automated WaterDragon® wet-cleaning and drying mechanism

A series of retractable washer nozzles are installed at strategic points within the mixing vessel. After discharging, the nozzles automatically protract from behind their air-tight closure flap. Driven by the pressure from the wash water, the washing heads rotate to spray down the interior of the mixing vessel. The system is designed to automatically drain itself of residual rinse water before funneling warm air into the vessel via the nozzles to completely dry the mixer.

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4 Conclusions

Veggie alternatives now occupy more shelf-space in grocery stores than ever before and have become permanent fixtures on the menus of some of the world's largest fast food chains. In light of the sustained growth that this market sector is experiencing, it is impossible to deny that plant-based foods are increasingly important to the future of the global food industry.

Though infinitely promising, plant-based food production has a ways to go before it can render animal agriculture obsolete. Additional time, resources, and expertise must be dedicated to fostering a diversified supply chain of plant-based protein sources. Furthermore, building out a high-volume production line that can accommodate diverse plant-based ingredients, processing steps, and product types requires extensive investment in manufacturing facilities and equipment.

As regulations on plant-based claims tighten and more financing begins to flow towards production environments, mixing equipment will come to play an increasingly central role in the plant-based foods movement. With unparalleled performance, hygiene, and flexibility, amixon® mixers are posed to help plant-based food producers truly revolutionize the way the world eats.

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