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INNOVATION

WHITE PAPER

Creating a framework for effective manufacturing innovation

Innovating around the manufacture of food and beverage products is hard. Process complexity, health and safety controls, and the burden of a legacy-installed base all present difficulties. Yet, the sector must adapt to rapidly evolving trends and demands. This white paper offers valuable insights into the various forces at play and proposes a simple model within which F&B producers can frame their manufacturing innovation projects.

Food and beverage supply chains are evolving, technology is advancing, and consumer demands are changing at pace. The cost, scale, and carbon footprint of manufacturing are also under the spotlight. In short, the sector needs to adapt food and beverage manufacturing processes to foster better agility and environmental sustainability. But this is easier said than done.

Part of the challenge lies in the complexity and scale of processes deployed in food and beverage manufacturing. As Figure 1 illustrates, manufacturing encompasses multiple elements, from raw materials handling to processing to filling and packing. Each presents its own innovation challenges and opportunities which can have repercussions up and down the supply chain.

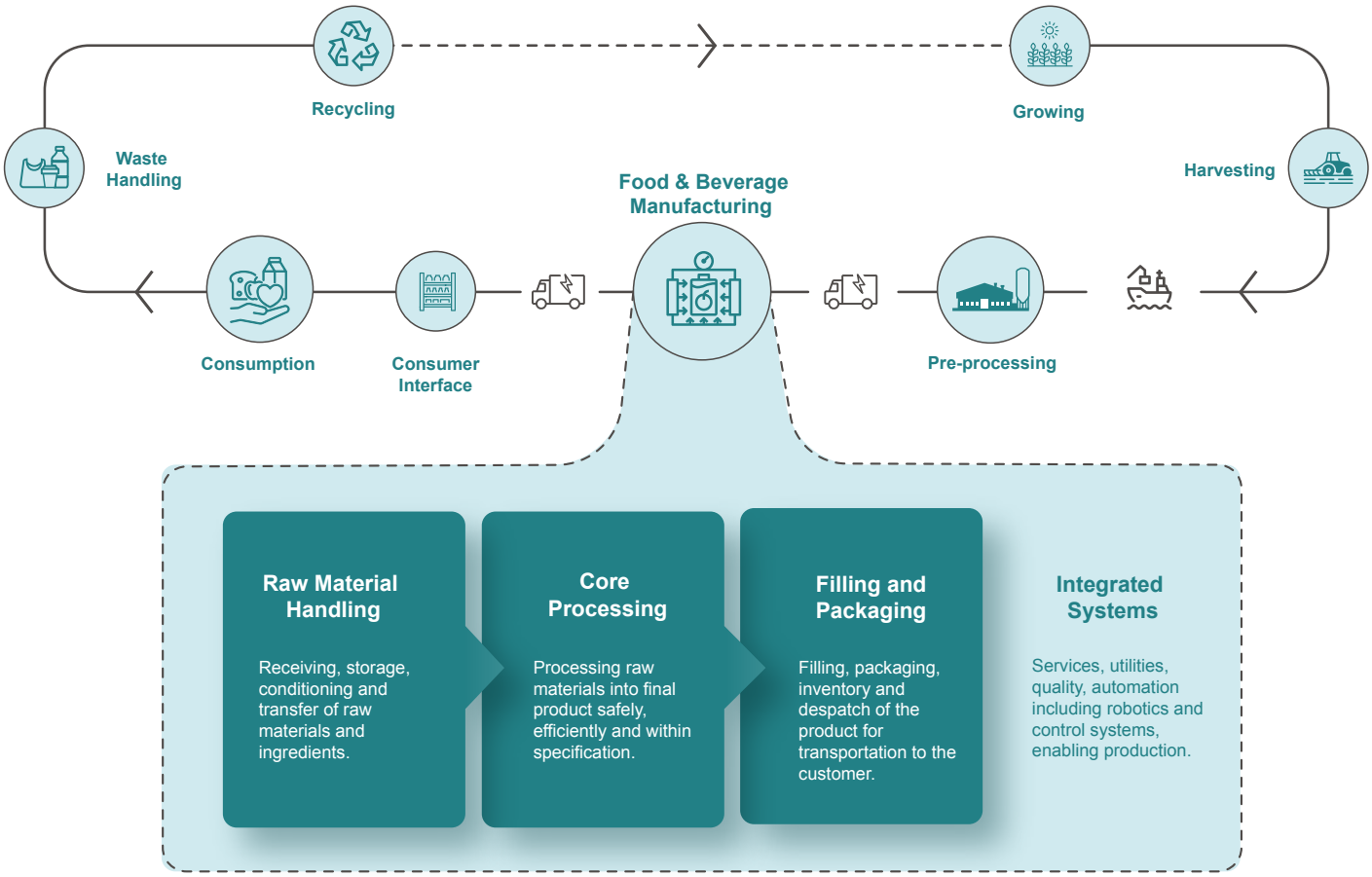


Figure 1: Manufacturing innovation in the context of current supply chains

This paper examines the various forces driving food and beverage manufacturing innovation to aid the navigation of this multifaceted space. Sagentia Innovation's goal is to help you make better risk-managed decisions as production is modernised to deliver competitive advantage while working towards sustainability commitments.

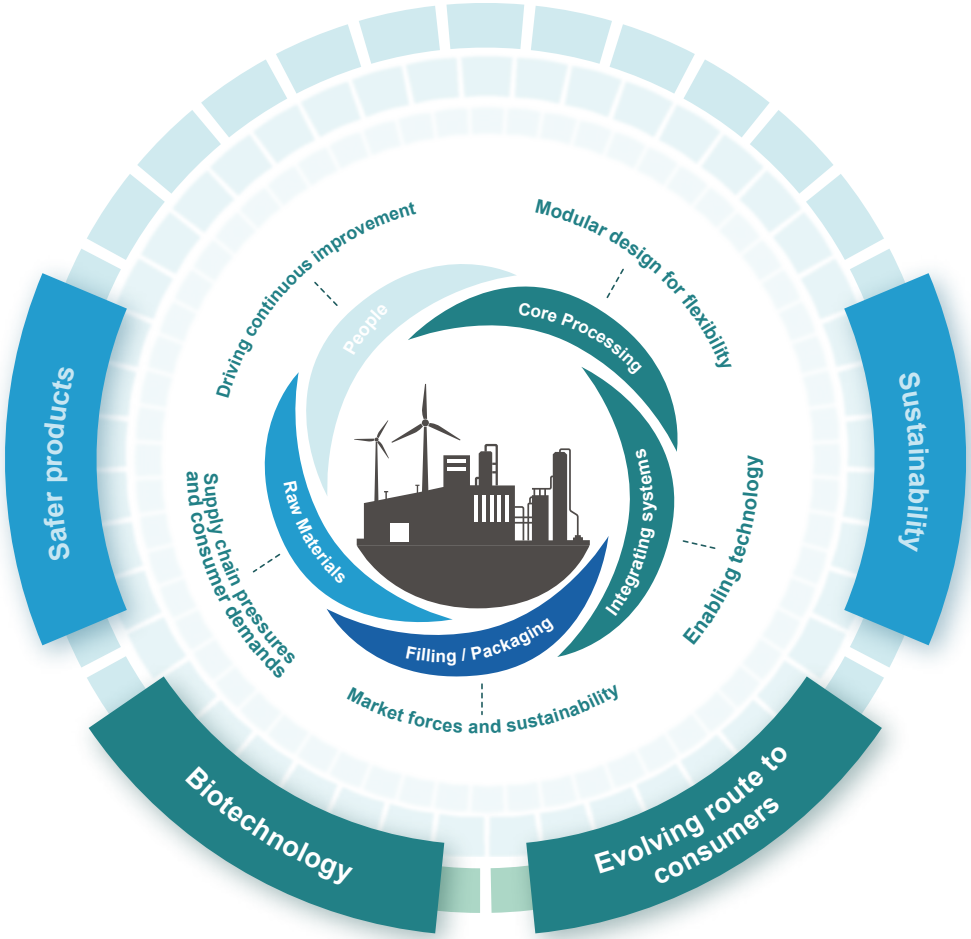


Figure 2: Recommended framework to support manufacturing process innovation

Using a framework within which to innovate both the core process and the integrated design in the context of a continuously changing external environment, would enable R&D, engineering and operations to take account of the key external forces. Food and beverage manufacturers often tend to focus innovation in their core processes in response to the product specification requirements.

Integrated process systems such as cleaning, heating/cooling or waste streams may have a much bigger impact on sustainability and flexibility. Therefore a change in approach may be required where the integrated design takes precedence.

It is common nowadays to use mathematical modelling and virtual testing to solve specific engineering problems, develop concepts or scale up processes. However, there is an increasing opportunity to use modelling for manufacturing process innovation and development by modelling the core processes, integrated design and even some of the key external forces. Within a manufacturing process model, new products could be tested to anticipate manufacturing efficiency, including, for example, the ability to meet product specifications, yield, defects and operating cost, as well as forming an understanding of sustainability-related parameters. A well-built model can be refined over time for greater accuracy and become a very valuable tool for R&D and operations to road-test new products or manufacturing process changes.

The forces at play

Today's headline trends range from sustainability and cost-saving to supply chain agility. Future food technology developments such as acellular and cellular production are also moving up the agenda. Specific priorities and concerns vary across markets, but understanding broader forces which will significantly impact manufacturing over the next five years is crucial.

Unsurprisingly, we see the most influential force at present as environmental sustainability, closely followed by the demand for safer products, which offer improved nutrition and avoid problem components, (although the latter is not always based on scientific evidence).

Net zero targets are shaping stakeholder priorities and strongly influencing investment decisions for many food and beverage companies. Applying heat pump technology, reducing water consumption, and boosting electrification are simple examples of the direct impact on manufacturing. However, putting sustainability at the forefront of investment strategy brings additional indirect impacts which may be subtle, yet equally valid.

In terms of product quality, attention is increasingly turning to nutrition and the potential health implications of product components such as sweeteners or stimulants. Whether a product is marketed as intrinsically nutritious, an occasional snack, or an indulgent treat, companies are endeavouring to continuously improve nutritional quality, while reducing ingredients or additives that are perceived negatively. Indeed, in many cases, components such as sweeteners are literally under the microscope with respect to cancers and other serious health concerns. This is further compounded by some influencers, who may propagate fears surrounding ultra-processed foods, with less regard for how the world could otherwise feed itself. As scientific understanding, regulatory controls, and consumer preferences evolve, manufacturing facilities need the capability to adapt to new requirements.

Two additional forces that we are monitoring closely are developments in biotechnology and the evolving product route to consumer. We expect both areas to have a profound and growing impact on food and beverage manufacturing in the medium or longer term.

As biotechnology processes such as precision fermentation gain a firmer footing, finding safe and feasible ways to scale their use is becoming a priority. At present, challenges linked to maintaining sterility and standards while controlling the inherent variability of biological systems play against the feasibility of large-scale production. However, this may be counteracted by policy change at the governmental level. Shifting subsidies from traditional, high carbon footprint agricultural practices addressing the high cost of production-scale installations, may change the dynamic and improve commercial prospects. When plant-based drinks cornered part of the dairy market, one strategy adopted by some dairy companies was to replace or upgrade production lines to accommodate plant-based alternatives. However, it is much less feasible to do so for biotechnology processes. Challenges surrounding biotechnology scale-up are explored in more detail at **sagentia.com/innovation-expert-insights**

In terms of route to consumer, practices may evolve to support products that are more personalised and less packaged, with a resultant shortening of shelf life. This is partly down to consumer preferences and acceptance of alternative models, such as direct-to-home. However, delivery capabilities influence the scope, scale, and pace of change too. In effect, logistics companies such as **DHL** and online marketplaces like **Amazon** are becoming 'pseudo customers' of food business operators, assuming a role similar to that traditionally adopted by supermarkets.

Home delivery of stable intermediate or concentrate products has the potential to significantly reduce or even eliminate packaging too. In the case of beverages, it could also eradicate most of the water (and therefore weight) being transported. Rather than purchasing 'finished' products, consumers handle the final stages of 'manufacture' at home. This may be achieved by means of dispensing or reconstituting with water or other ingredients, using air fryers, microwaves, or indeed technologies not yet invented, to complete the production process. As further progress is made in consumer delivery logistics, the conventional wisdom of 'raw materials in; processing; goods out in primary packaging' is likely to be disrupted.

Advancements in transportation will likely create new options and expectations, both in terms of product specification and product delivery. DHL's biennial foresight report is a useful reference when considering how logistics innovation could impact food and beverage manufacturing transformation. Its Logistics Trends Radar suggests outdoor autonomous vehicles will have a high impact over the next five to ten years. Developments in logistics will also place new demands on food and beverage packaging, such as the adoption of Internet of Things (IoT) technologies at the parcel level. Sagentia Innovation's white paper focused on packaging innovation is available at **sagentia.com/innovation-expert-insights**

Implications for food and beverage manufacturing

As these forces continue to exert pressure on food and beverage manufacturing, we anticipate that two prominent manufacturing trends will shape process technology and solution innovation: Widening the range of process capability to foster agility and adaptiveness will be a primary objective, and environmental sustainability will remain a core requirement, so technology and its operation, will need to evolve such that carbon emissions are reduced.

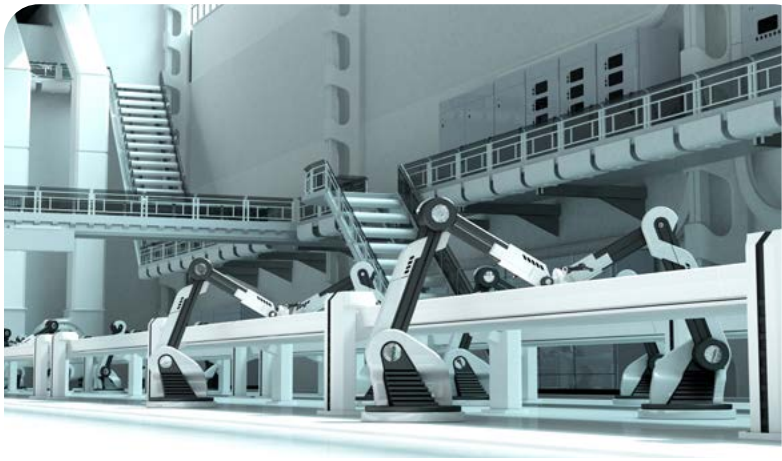
i. Safer Products – fostering agility and widening process capabilities

Existing installed base has generally been designed for the production of specific food and beverage formulations. However, formulations are evolving more rapidly than in the past to address nutritional demands and preferences.

Incrementel formulation changes don't usually present problems for manufacturing. Control system adjustments may be required, and there might be a small reduction in yield, or an additional processing step may be implemented. This can often be accommodated without significant investment or disruption to production lines.

Sometimes though, more substantial reformulation is necessary. Looming legislation with tax implications, mandatory phase-out of an ingredient, or the impact of consumer influencers can necessitate major change. In these situations, an entirely different method of processing might be needed. Take the reduction of a product's oil content; this may drive a transition from frying to a baking process. Similarly, a dairy plant's diversification into plant-based products may require the introduction of entirely different processing steps with the use of enzymes for example.

The emergence of new or reformulated products has always been a factor in manufacturing evolution. However, the rate at which product formulations are now changing presents a significant challenge. To a degree, the limitation of existing manufacturing systems acts as a guardrail for new formulation development, but this cannot happen indefinitely, and process technology providers who develop more adaptable solutions are likely to reap benefits in the medium term.



ii. Embedding environmental sustainability

Ever more sophisticated control systems, enhanced with AI and machine learning, make it easier to establish the carbon footprint of individual product and process elements, bringing a higher level of transparency. Regulators will persist in the introduction of tougher rules, pushing large food and beverage players to set higher goals and stretch their capabilities. Larger players will also continue to place expectations on themselves as they look to play a lead role in the journey to net zero.

Many technology developments have already helped reduce manufacturing facilities' carbon emissions and environmental harm. Installing solar panels, using more efficient motors for processing equipment, or changing the chemicals used for cleaning all have a positive impact. But this only delivers incremental improvements. To achieve carbon-zero or even carbon-neutral manufacturing, a more fundamental shift is required.

Sustainability needs to be designed into manufacturing solutions from the outset. In other words, it must be fully embedded and integrated.

Simultaneous development of core and integrated processes will play an enabling role here. Naturally, operators are experts in their plants' primary production processes. However, it's often the processes that integrate and surround them (for example, cleaning, heating/cooling, power, air compression, materials movement etc.) which have a greater bearing on sustainability. To satisfy the dual demand for flexibility and sustainability, both core and integrated process design need to be developed in unison, and therefore a framework to support this is recommended (see Figure 2). In fact, it is possible that the integrated manufacturing design will increasingly dictate how core processes are developed to ensure sustainability targets are met.

Heat pump technologies are a case in point. They hold much potential, but core processes will likely require altered design features to make them feasible. This may necessitate the introduction of different temperatures, pressures, capacities, scheduling, or even different manufacturing steps, all without undue impact on processing performance. We expect the transition to electrification and evolution in cleaning system design to have a major impact on core process design.

When could a step change happen?

Acknowledging when core processes are constraining product development and identifying where the integrated process design can be upgraded to meet sustainability targets enables more significant change to be implemented. It's about strategic investment in major advancement rather than the incremental evolution of processes. This can be seen in other sectors too, as evidenced by the automotive industry's development of electric vehicle battery 'gigafactories'. In food and beverage manufacture, new technologies such as co-bots and computer vision are likely to be employed, reducing the level of human intervention, while further enabling advanced modular design and more compact production combined with minimised inventory. These developments, aided by advanced delivery systems, will likely result in significantly higher output from the same factory footprint. In keeping with the current trend for investment in existing plants rather than greenfield sites, the innovation challenge centres on process adaptation as much as the development of new, standalone systems.

Changing what happens in the factory

All these influencing factors demand greater flexibility in food and beverage supply chains and within the factory. As the key step in product formation, manufacturing must accommodate different processes and formulations while continuing to satisfy production volumes, HACCP principles, and profitability goals. Steps taken over the next five years will set the stage for facilities' longer-term performance and companies' commercial success.

Here at Sagentia Innovation, we apply deep science and engineering-led approaches to support effective, cost-efficient manufacturing innovation. Future insight articles will focus on specific examples of how to innovate for a step change in flexibility and carbon footprint, creating win-win opportunities including a strong commercial justification. In the meantime, you can find out more about how we support clients' food and beverage processing innovation at **sagentia.com/innovation**

About Sagentia Innovation

Sagentia Innovation provides independent advisory and leading-edge product development services focused on science and technology initiatives. Working across industrial, chemical, energy, food and beverage, and consumer markets, Sagentia Innovation works with start-up disruptors through to world leading brands to extract maximum value from R&D and innovation investments.

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