Technology Landscaping in Indian Meat Sector to Meet the Future Demand and Strengthening Business

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ABSTRACT

The meat industry is influenced by technological developments which should be accepted by the stakeholders/consumers' and it should be feasible as consumers' preferences are one of the most important factors. Technology plays a crucial role across the entire lifecycle of a product, and communicating it in a translucent way is significant for building brand loyalty. Adapting to new technology can be game-changing and a thorough, in-depth view of a technology space is needed to make the right decision. Technology landscaping involves examining and outlining the landscape for technology by uncovering trends, research gaps, overlaps, and links and is also helpful for directing research and developing strategy. Technology landscape maps can help to build awareness of strategic technologies and identify opportunities at the intersection of emerging technologies and customer needs. Today with modern disruptive technologies, the food industry is booming. While the meat industry was a late adopter, companies are currently seeking to transform themselves digitally through better data collection and more control over their machinery. Technology landscaping has provided the best solutions to the existing problems in the meat sector. The recent Industry 4.0 technologies like Big Data, Artificial Intelligence, Internet of things, Blockchain Technology, and Robotics are being used in the livestock sector to enhance farm automation, clean meat production, and transparency throughout the supply chain right from the manufacturer to the end-users. Despite having these all-lucrative advantages of emerging technologies in the food sector; the adoption of technology is at a very slow pace. The main reason behind this is the higher initial investment, paucity of skilled manpower, and maintenance of relevant protocols. Another thing is majority of meat processors are small and medium-sized organizations. Technology has the potential to change the competitive landscape in the market and as technology disrupts the market there will also be discontinuation of the present market structure.

INTRODUCTION

The food consumption pattern of people is based on various factors like habits, purchasing power, and own traditions and beliefs. In the meat industry, consumer preferences are one of the most important factors. Studies shows that the consumption of meat has reached 300 million tons and the growth projection for consumption is 76% by 2050 (Zhang et al. 2021). Adapting to new technology can be a game-changing decision. Because of the speed at which technology changes today, making the right technology choice is critical to success. A thorough, in-depth view of a technology space is needed to make the right decision. Landscaping identifies trends, gaps, and areas of overlap, and assesses the technical maturity of potential solutions as they relate to unique needs. The broader technology landscape is already shifting from a traditional manufacturing automation stack to an 'industrial internet of things' (IIoT) stack, which leverages a combination of app development, platform cloud, connectivity, and hardware. Even though changes are happening fast in most of the sectors, the meat retail industry lags behind when incorporating technology into its business model.

TECHNOLOGY LANDSCAPING

The technology landscape was introduced by Jay Paap in 2010. It is a process that reviews, analyzes, and determines the various discoveries and inventions that can best fit our business goals. It helps in ascertaining the viability of the existing as[1] well as new products for production and market requirements. Technology landscaping involves examining and outlining the landscape for technology by uncovering trends, research gaps, overlaps, and links and is also helpful for directing research and developing strategy (Spitsberg et al. 2013). It conveys the technology trends and creates a map for business strategy. It helps to make an informed decision by viewing the clear picture regarding the competitive advantage of the technology. It is to understand how the technology is evolving, how best it is put to use, or even the ability to drive an extension of a present technology of a product or process.

IMPORTANCE OF TECHNOLOGY LANDSCAPING

It usually sets the stage for the next round of product advancement and it thus has great potential to disrupt a market. So, understanding the technology landscape is always important, no matter how simple a marketing effort may appear. This trade-off between predictability and innovation can be visualized as a "technology landscape," with gently sloping hills corresponding to incremental product improvements (Paap and Kartz 2004). Technology landscaping will have access to a unique skillset dedicated to identifying and analyzing the technical information required to make strategic roadmap decisions. The most reliable way to forecast the future is to understand the present. It helps to identify technology trends and emerging technologies and identify

current and future competitors. It identifies future R&D partners or experts and explores opportunities for future business development. It allows to track trends over time and decide how should respond to the market and what other competitors are doing. Technology landscaping specifically improves the performance or seeks ideas, processes, or technologies from other sectors. It evaluates potential technology investments and determines which path offers the greatest return and assesses complex regulatory, competitive, and technology factors. It considers alternative ways of approaching a problem when a shift in the market occurs.

RELEVANCE OF TECHNOLOGY LANDSCAPING IN THE MEAT INDUSTRY

Meat production is largely an unorganized yet vital segment of Indian agriculture. Traditional production systems and disorderly practices have flawed the image of the Indian meat industry. The unregulated meat markets, tropical climate, inadequate slaughterhouse hygiene measures, and the lack of surveillance of meat-borne diseases enhance the risk of occupational hazards. There are more than 20,000 unregistered slaughterhouses are there in the country which does not take prophylactic measures for hygienic/ clean meat production. Meat production in the country has increased from 6.69 million tons in 2014-15 to 8.80 million tons in 2020-21. Indian buffalo meat production raised by 7% and India's 2022 buffalo meat export are forecast at 1.5 million tons up 9% compared to 2021 (USDA 2021). Apart from slaughtering, the meat value chain faces various challenges. The retail sector in the fresh meat supply chain is also not promising and consumers' acceptance for chilled and packaged meat is very lower as compared to the global average.

Though India has an abundant supply of meat, the processing industry is still emerging and innovative research is required for newer and traditional product development as needed and demanded by the consumers (Sen et al. 2021). The sudden outbreak of COVID-19 led to a huge gap between the supply and demand of meat products, a reduction in slaughterhouse capacity, and exporting of meat to other countries, which has shown an impact on increasing the prices of meat (Girish et al. 2019). However, this pandemic has boosted a lesson for healthy

foods and consumers' attitudes had a sea change resulting in the huge e-marketing services in the meat sector (Pillai et al. 2021). Research has shown that there is a lack of transparency in the meat supply chain. To ensure that the right product reaches the right consumer, traceability techniques have to be adapted. The traditional meat production practices and preserving techniques have reduced the shelf life of various value-added meat products. Meat processing and value addition are key to the prosperity of the meat industry. In addition to the value-added meat products, India is also supplying frozen and chilled meat products, which are having a huge demand in international markets. Hence there is a need to introduce modern technologies of value addition and smart packaging and preservation to improve the shelf life of the products. To address the challenge of clean meat production and to minimize the human intervention; it is necessary to automate the entire meat production process either by using robotics or advanced types of machinery.

TECHNOLOGY LANDSCAPE MAPPING

Technology landscape maps can help to build awareness of strategic technologies and identify opportunities at the intersection of emerging technologies and customer needs. It is a valuable tool for visualizing the relative position and maturity of key external technologies and how those technologies relate to internal product initiatives (Phaal et al. 2004). Landscape mapping should be viewed as the "homework" that enhances business development. It requires for any given strategic business development objective (e.g., entering a new market segment, adding a new product category to an existing portfolio, or bolt-on acquisitions, etc.). The Open Innovation landscape mapping process leverages know-how and opportunities outside of an organization, and combines external knowledge and innovation, with internal ideation, to capture and create value (Chesborough et al. 2006). In an Open Innovation model, it is assumed that valuable ideas and new opportunities can be found from the distributed research and development community external to an organization. It is combined with internal know-how and integration of external and internal expertise can lead to much more attractive outcomes, both in terms of quality of innovation, and in terms of timeline and cost needed for bringing innovations to market.

Technology Mapping in Meat Sector
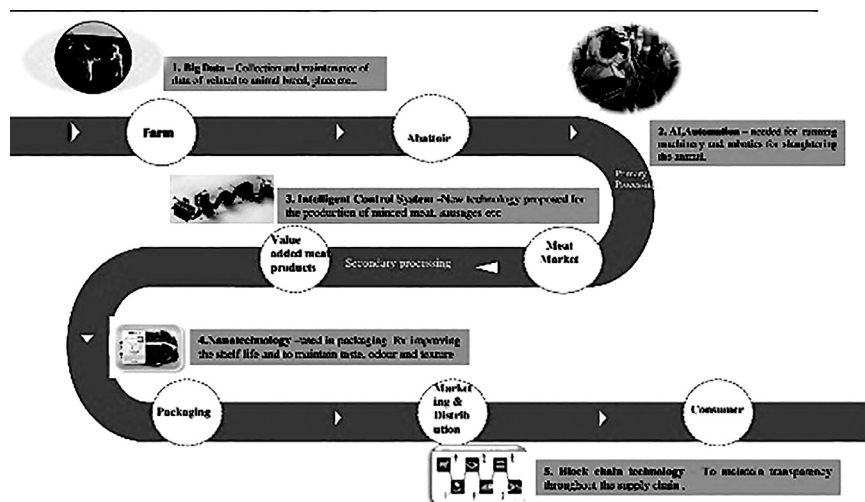
RECENT TECHNOLOGICAL ADVANCEMENTS IN THE MEAT INDUSTRY

In every industry, the primary reason companies adopt new technologies is to improve efficiency. Today modern disruptive technologies, the food industry is booming. While the meat industry was a late adopter, companies are currently seeking to transform themselves digitally through better data collection and more control over their machinery. Technology landscaping has provided the best solutions to the existing problems in the meat sector. Automation can be done in both primary processing and secondary processing unit. The recent Industry 4.0 technologies like Big Data, Artificial Intelligence, Internet of things, Blockchain Technology, and Robotics are being used in the livestock sector to enhance farm automation, clean meat production, and transparency throughout the supply chain right from the manufacturer to the end-users.

BIG DATA

Big data is becoming more prominent and it is used, for collecting information and maintaining the data. The sensors are connected to various algorithms, to capture and process lots of data quickly which is later summarized to develop action plans (Neethirajan 2020). In a meat plant, capturing the image of each animal creates a large dataset used for grading, defect tracking, decision-making about cut-up parts, and deboning. It allows the management to maximize plant utilization. The information can also be merged with real-time meat prices and take advantage of price variation, to improve marketing decisions. The huge data can be used for beef and pork, in grading (marbling, fat thickness, and loin surface area), for estimating yield, pointing out defects (bruises), and later even monitoring genetic potential (Teixeira et al. 2021).

BLOCKCHAIN TECHNOLOGY

One of the trends driving technology into the meat and poultry sector is the need for digital know-how in areas like blockchain that can improve efficiencies and profits. The vast majority of venture capital is flowing into precision crop agriculture but the meat side is the least digitized segment especially in developing nations. So, there is a huge opportunity to make today's processes more efficient and effective using digital technology. It is a decentralized network based on cryptography that uses peer-to-peer consensus to validate transactions. In short, a system enabling international sales of meat to consumers who are increasingly demanding about the provenance and health of the animals whose meat they are eating, and the social impact of the product they are buying, by using encrypted time-stamped blocks and electronic records were preventing after-the-point data manipulation. A Blockchain creates transparency and enables faster decision-making (Sander et al. 2018). Its implementation in the meat supply chain will make it easy for all the stakeholders to trace the provenance of the meat.

Valid providence credentials helps to increase the brand's reputation and perception in the consumer's mind. This increases the consumers' willingness to pay, thereby increasing revenue. It is required for Supermarket retailers to collaborate with players in the meat industry to implement blockchain technology across the retail meat supply chain. By sharing consistent information with all supply chain participants, the Blockchain reduces the duplication and incompatibilities across communication points and manual processes which delay the shipment of goods (Shahbazi and Byun 2021). It disrupts the current methods used to convey food quality and safety adherence and will differentiate by enhancing traceability and trust. It boosts the communication of sustainable and ethical farming practices and conveys the health benefits of meat consumption to consumers in a trustworthy and sustainable manner.
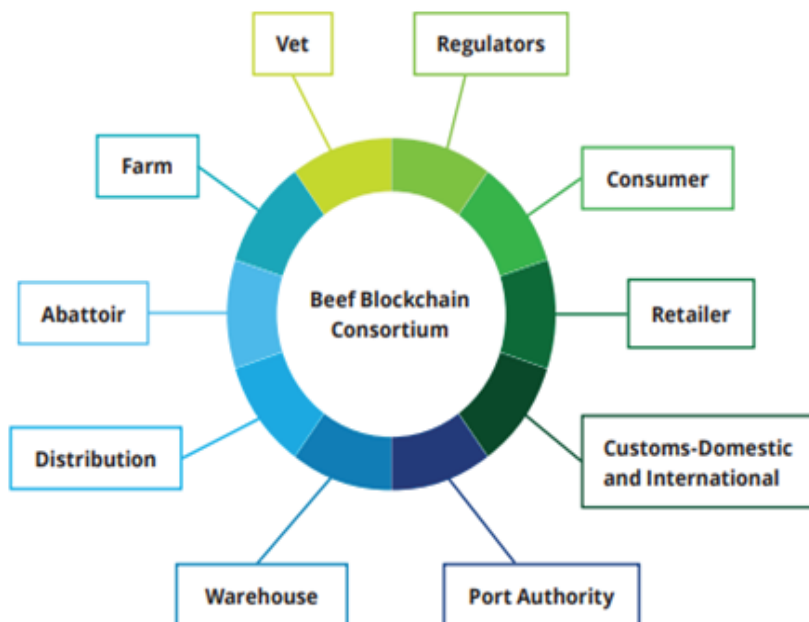
(Hancock 2019)

ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) and machine learning are changing the methods of food production and both are used to improve the safety and quality of the product. They allow the system to identify and remove even hard-to-spot foreign material in-stream and also allow the system to measure and respond to product quality measures like fat/lean ratio, pH, and freshness and even identify myopathies like a woody breast. AI technology has great potential to detect marbling in beef and pork (Liu et al. 2018), fresh colour of pork (Sun et al. 2018), tenderness of beef, and grading of beef fat colour. Artificial Neural Networks are one of the technologies that have been applied for solving the problems in meat industry like sensory testing (e.g. analysis of odour or flavour), to handle complex properties (e.g. meat tenderness), speeding up the process or replacing human operator in the on-line inspection. Through this technology, the process of slaughtering and packing the meat is atomized, which reduces human intervention. An artificial neural network (ANN) was developed to predict the temperature and moisture content of frankfurters during smokehouse cooking (Mittal and Zhang 2000).

INTELLIGENT CONTROL SYSTEM

The traditional technology for production of minced meat and finished product is mainly based on the operator. The new technology is forecasted for the production of minced meat, sausages etc. is integrated control system. This system completely automates the line and envisages complete automation of the technological process (Ma et al. 2015). This technology will help in producing finished products of guaranteed consistency and high quality. Machine control of the minced meat produced for sausages at all stages of its production ensures the high quality of the final product. Full automation of the technological process of minced meat production using the proposed control system opens the way for the design of automatic meat processing plants in the future (Kapovsky et al. 2020).

From farm to table, production of meat products for consumers is a highly sensitive procedure that requires immense consideration at every step along the line. To keep products safe and consistent, meat, poultry, and seafood processors must implement measures that can control variables, prevent outside interference and keep parameters the same for every product batch (Duda 1997). Avoiding contamination risks and preventing inconsistencies in product quality is challenging for any food manufacturer. Adopting the right process control strategy has made easier by knowing the factors to watch out for and by utilizing the right technologies, including automated equipment.

ROBOTICS

Automation again comes into play through sophisticated equipment that can sort items carefully based on characteristics such as weight and shape. New robotic cutting equipment ensures more even cuts and portions of meat, even when slicing through different textures, densities, and shapes. Automated slicers and shredders are also becoming popular among meat, poultry, and seafood companies. Robotics and automated equipment can be used at the stage of inspection, where advanced vision equipment can detect shards of metal, foreign objects, or other harmful particles that could go unseen by a worker's naked eye (Alvseike et al. 2018). Automated clean-in-place (CIP) software can standardize the sanitization process and sterilize with a measured amount of cleaning agents, and set temperatures and durations. This type of technology minimizes potential bacterial growth and keeps contaminants at bay for abattoir and meat processing plants.

Automation can now be seen in both primary and secondary processing of meat, but implementation depends on factors such as cost, and availability of a labour force. Meat can now be processed by automated machines and robots, almost without human intervention. Meat cutting is one of the most hazardous food manufacturing operations for both worker and product safety. Generally, automation can be embedded into and throughout the whole process, from production to slaughtering to processing. Automation and robotics can mitigate the labor situation, not just in taking up human employees' place but also in providing less laborious jobs and more of an oversight and management of systems (Esper et al. 2021). This includes automatic rib pulling and cutting systems that will provide value via vision and X-ray technologies which help in selecting the optimum rib cut from the pork belly, improving yield. Activities like deboning, cutting out beef or chicken filets, and others still require the dexterity of the human hand and the human eye, so there is ample scope for innovations in this area too. Beyond handling unwrapped products, robotic packaging systems have been successfully implemented in primary packaging, casing, stacking of cases into pallets, and arranging the pallets in the warehouse. After primary processing, placing processed products into individual containers is the first step in packaging which uses picking robotic hands (Wang et al. 2022).

INTERNET OF THINGS (IoT)

Food safety is closely related to health and recently the use of information technology to ensure food safety has become a hot research topic. The internet of things monitor platform is a new idea for food safety in the meat processing industry (Hu et al. 2011). During the sausage production process, a monitor platform can be built based on the internet of things through video surveillance technology, sensor networks, and GPS. IoT contains functionalities such as data processing and storage, as well as specialized functionality, per application and service, since emerging services have different requirements (Bouzembrak et al. 2019). Based on Hazard analysis critical control point (HACCP), the key control points of the sausage production process are determined, and then the internet of things monitor platform can be used by monitoring all the critical control points (CCPs), to ensure the food safety during the sausage production process and provide food trace function.

3D PRINTING TECHNOLOGY

The three-dimensional printing (3DP) process stands as a developing technology for food manufacturing, which offers the opportunity to design novel food products with improved nutritional value and sensorial profile (Dick et al. 2019). 3D food printing supports product innovation, on-demand production, and customization. The technology enables consumers to eat fresh and healthy dishes, create new eating experiences, and customize food preferences in shape, colour, flavour, texture, and nutrition. The emerging technology of 3D printing (3DP) has been recognized for its unprecedented capacity to fabricate food products with intricate structures and reduced material cost and energy (Ramachandraiah

2021). The main challenges include process productivity, flexibility in production, and product innovation and functionality. It is also known as food layered manufacture (FLM), is an exciting new method of digital food production that applies the process of additive manufacturing to food fabrication. In the 3D food printing process, a food product is first scanned or designed with computer-aided design software and produced by splitting the designed object into thin layers. The 3D food printing process can also allow the consumer full control of shape, colour, flavour, texture, and nutrition for food customization.

It offers numerous possibilities for the development of tailored animal protein-based structures and products including flexibility in geometries, textures and flavours and customised nutrition. Technology for the production of 3D printed meat products necessitates the reduction of particle size of meat and dilution of meaty and savoury flavour and this is generally expected to reduce the value of premium meat products. However, the technology might be a good option for utilization of lower value and tougher cuts and trimmings. The need of the hour is to focus on the development of 3D printed meat products with multiple flavours, colours and intricate texture to make these products popular among consumers and the overall success of 3D printing technology in the meat sector (Jandyal et al. 2021).

THE RISE OF SMART PROTEINS

Global challenge is clear, to feed the world's growing population expected to reach more than 9.1 billion by 2050. With meat consumption showing no sign of slowing down and the unlikely event that society will become 100% vegetarian in the coming years, the search for sustainable meat alternatives is needed (Letti et al. 2021). The world's population of 7.5 billion is already pushing against the limits of the planet's resources. From plant-based and insect proteins to cultured meat, alternative proteins have truly rattled the meat industry. With increased media attention around the unsustainable and environmentally damaging effects of the animal sector forward-thinking start-ups, investors and scientists are challenging the future of traditional meat (Ramani et al. 2021).

Smart proteins generally fit into three categories: plant-based products, fermented products, and cultured meats. Plant-based products closely resemble animal-based products but are made from ingredients derived from plants such as chickpeas and soy (Vliet et al. 2020). Fermentation refers to the cultivation of any microbial species. This is a process that has long been used in the food industry to produce products like cheese and yoghurt. Regarding alternative proteins, microbial fermentation can produce a variety of products. Cultivated meats are produced through the cultivation and expansion of animal-derived muscle cells, producing a product that mirrors the nutritional and sensory profile of traditional meat. For cultured meats, many technological improvements are still required to be developed. Due to the costs involved in the research and experimentation, cultured meat is having a slow start (Bhat et al. 2015) Economic and sustainability issues are a concern and intense research efforts in these fields seem warranted to support the best choices. While in the long-term, lab-grown meat might become mainstream in India, at the moment the Indian market is not ready to pay a premium for meat alternatives.

DIGITALIZATION IN THE MEAT SUPPLY CHAIN

The business of delivering ready-to-eat foodstuffs from restaurants to homes is undergoing a sea change as new online platforms enable food providers to capture markets and customers day by day (Thamaraiselvan et al. 2019). There are immense opportunities for digitalization in the meat industry. Although progress has been underway for many years, the global pandemic has dramatically accelerated the rate of change. Smart solutions have been key in responding to the rapidly changing environment, and most businesses have ramped up their investments accordingly. It is well understood across the food industry that modernization, including investment in data infrastructure, is an essential first step towards digitalization. Digitalization is the key enabler for new business model innovation across the meat supply chain. The meat supply chain should be regularly monitored to ensure the safety of products (Nastasijevic and Moracanin 2021). This will help drive real-time planning and visibility, optimized inventory replenishment and ordering, reduced waste, and better customer experiences. Now private players are also aware of increasing competition and taking several new technology initiatives to maintain the momentum. One of the new technology initiatives that they are undertaking is building its chatbots and leveraging data science to analyze every customer interaction in real-time. Maintaining every aspect of quality is highly critical for the company. They are building technology where every customer call will be recorded, converted from speech to text, and analyzed in real-time to resolve the issues proactively. The industry has been looking forward to the new era of its growth, pondering the best ways to collaborate in the hybrid era and strictly adhering to continuous improvement as a critical business strategy to further create, personalize and optimize customer experiences at every stage of their interactions. Internally, it has swiftly adopted a hybrid workspace model and deployed new tools for effective collaboration.

CONCLUSION

With an increasing world population, an increase in affluence, and a substantial growth in the demand for high-quality protein, the meat sector faces a fantastic but challenging century. New scientific knowledge, technology, and creative minds are the main ingredients to reach out for this great opportunity. The scientific meat society must provide knowledge and technology to reach out for a seemingly bright future. Technology plays a crucial role across the entire lifecycle of a product, and communicating it in a translucent way is significant for building brand loyalty. Across the bottom of the Food Supply Chain Tech Industry Landscape, need to be included a variety of value chain players which integrate across multiple pillars including a value chain platforms, enterprise supply chain platforms, traceability, integrated business planning, and networked supply, trade, and logistics platforms. The major benefits of the recent technologies are the improvement in resource efficiency, cost reduction, market access, customer satisfaction, systematic management, enhanced food safety, and transparency. Despite having these all-lucrative advantages of emerging technologies in the food sector the adoption of technology is at a very slow pace. The main reason behind this is the higher initial investment, scarcity of skilled manpower, and maintenance of relevant protocols. This is because the majority of meat processors are small and medium-sized organizations. Technology has the potential to change the competitive landscape in the market and as technology disrupts the market there will also be discontinuation of the present market structure.

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