Innovative approaches in the field of meat production

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Abstract. In modern times, the use of some technological equipment (artificial meat, proteins of various insects) is important to meet the demand for meat products. Effective use of interactive technologies, along with the process of disposal of waste products in the meat industry, is preparing a solid foundation for the meat industry. Efficient use of resources, ecologically clean product, and canning process create a foundation for continuous innovative development of the industry. Artificial meat is playing the role of promising food for the future, but there are health effects of artificial meat. The use of insect proteins along with meat analogues creates alternative solutions to the problems that will arise in this field. Since researches on the meat industry are a minority in modern times, the article can be considered relevant. Keywords: Innovation, meat, industry, production, effects

1 Introduction

Due to the negative image that the environmental effects caused by the growth in the livestock sector and ethical concerns about animal welfare have imposed on meat products, which have been adopted as the primary protein source from past to present, solutions aimed at ensuring sustainable production have been put forward. Although diversifying protein sources, in other words, searching for alternative protein sources, is the first solution that comes to mind in order to reduce the need for meat, it will be very difficult to change human habits that have been going on for centuries. Therefore, researchers have come up with the idea of reversing the unsustainable conditions caused by the livestock industry with environmentally friendly animal breeding systems and innovative meat processing technologies (Andonovic et al., 2018).

In this respect, the first alternative applications that come to mind to meet the increasing demand of consumers for meat and meat products are substitutes with protein sources such as artificial meat, insect protein and meat analogues. In addition, it is anticipated that the use of innovative meat production, processing and preservation systems, which are compatible with animal welfare and operate according to the principle of minimum negative environmental impact, will play an active role in sustainable meat production, instead of traditional meat production methods with a negative environmental image. In this study, innovative green solutions for the future for sustainable production in the meat sector. The systems developed to provide a sustainable supply chain in which traditional practices are

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reviewed and integrated with social, environmental and economic goals, and meat alternative innovative approaches in reducing the demand for traditional meat are examined by including current researches.

2 Establishment of a sustainable meat supply claim

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2.1 Smart farms

Thanks to the Internet of Things (IOT), which is the biggest benefit of the industry 4.0 revolution, which provides the basis for the establishment of smart industrial systems, it has become possible to implement environmentally friendly and smart farm designs that produce in accordance with animal welfare principles under sustainable conditions. IOT technology, which is the driving force of industrial reform, is basically an innovative technology that enables technological products such as sensors, cameras, mobile phones and computers to interact with each other and work in harmony to achieve a common goal (Pan et al., 2016). In large-scale farms containing thousands of animals, it is very difficult to monitor the movement, feed consumption, pregnancy process and disease status of each animal individually. In addition to the solutions it brings to these difficulties, the use of precision herd management systems (Precision Livestock Farming), which reduces costs, ensures efficient use of resources, and therefore aims to increase production, is becoming increasingly common. While not being able to detect the infectious disease seen in a single animal in the herd due to the inability to regularly monitor each animal in traditional farms affects the whole herd, excessive use of antibiotics may be resorted to to prevent this problem from occurring. Thanks to sensitive herd management systems, which replace these practices that put public health at risk, it is aimed to protect the health of the herd by monitoring the environment, health and nutritional status of animals (Zin et al., 2020). This practice, which encourages socially, economically and environmentally sustainable animal husbandry, also serves purposes such as making the most of the individual capacity of animals, minimizing the use of drugs with preventive health measures, and protecting the herd with early diagnosis in case of disease (Vranken and Berckmans, 2008). 2017). These systems enable the monitoring of environmental conditions with cameras, microphones and sensors (3D accelerometer, temperature and humidity sensors, etc.) placed in the farm, and the conversion of muscle, neck and wrist movements into data thanks to smart wristbands attached to the ears, necks or ankles of animals. Every time the animals enter the receiving areas of the base stations installed in the farms, the measured data is downloaded to the host wirelessly using IOT technology. Thus, the data obtained from each animal becomes continuously traceable in the cloud-based software environment (Andonovic et al., 2018). These smart wristbands, which reveal normal behavior patterns, send a warning message to the farmer immediately in case of deviations from normality, making it easier for farmers to monitor their herds from afar and use early intervention methods when necessary.

2.2 Genetic arrangements

Instead of increasing the number of animals in meeting the demand for meat and meat products, producing genetically selected livestock with high slaughter weight, maximum growth rate and optimum carcass composition can play an important role in reducing the environmental impact of the livestock industry (Grandin, 2019). As a result of genetic studies carried out from the past to the present, while the production of offspring in pigs increased by 50%, it was observed that the amount of lean meat of the offspring increased by 37% compared to local breeds. In addition, the meat yield obtained as a result of 1 kg of feed consumption in these animals has doubled compared to the past. With artificial selection in poultry production, the time required for chickens to reach 2 kg of weight has been reduced from 100 days to 40 days. The feed consumption rates of chickens obtained as a result of selective breeding decreased by half, the amount of breast meat increased from 12% to 20%, and the amount of eggs obtained per year increased by 30%. In the cattle industry, artificial selection increased milk yield by 67% (Tait-Burkard et al., 2020). Genetic studies enable high-efficiency production to be made with fewer animals, and to reduce feed consumption by using genetically selected high-yield animals. Thus, it will be possible to reduce the amount of greenhouse gas emissions released into the environment due to the increased use of agricultural land due to the increase in the capacity of the farms and the high number of animals. On the other hand, the fact that artificial selection interrupts local production and causes loss of biodiversity is considered by opposing groups as a situation against sustainability (Tisdell, 2003).

2.3 Waste disposal

In order to meet the increasing energy needs of modern smart farms equipped with up-to-date technologies, there are environmentally friendly designs that include the use of innovative sustainable energy sources. Fossil fuels, one of the non-renewable energy sources, are no longer sufficient to meet the increasing energy demand in parallel with the rapidly growing world population. Since these fuels have negative environmental effects such as air pollution and global warming, the search for alternative sustainable energy sources has gained importance. Animal wastes, which are produced daily in tons of farms, have the potential to be an alternative renewable bioenergy source. Biogas is produced from animal waste in an anaerobic environment on the basis of microorganisms breaking down organic matter (Cremiato et al., 2018). As a result of this process, a solid by-product called digestate, which has the potential to be used as organic fertilizer in greenhouse cultivation, is formed. The obtained biogas can be used to supply the electrical energy required for the farm to produce (Khalil et al., 2019). In addition, the evaluation of wastes such as blood, bones, shaving waste, and mechanically separated meat resulting from meat production in the production of collagen, protein hydrolyzate and bioactive peptides are also practices that can contribute to sustainable production (Mora et al., 2014).

2.4 Innovative processing and packaging technologies

Considering the presence of foodborne pathogens in perishable foods such as meat and meat products, effectively reducing the risks and preventing possible food waste; In addition, a number of innovative processing and preservation technologies have been developed to meet the consumer's demand for minimally processed, fresh food with good quality, safety and long shelf life, some of which have been introduced to industry. Applications such as high hydrostatic pressure, accentuated electric field, cold plasma, ultrasound, radiofrequency, microwave, ohmic heating stand out as sustainable innovative meat processing and preservation technologies. In addition to extending the shelf life by preserving product quality features, these technologies are also able to produce foods that meet consumer expectations in terms of sustainability with the minimum environmental impact and low energy consumption they provide. High hydrostatic pressure (HPP), which finds the most application in meat technology, is a non-thermal food preservation technology based on the application of high pressure (100-1000 MPa) for the inactivation of foodborne pathogens (Barbosa-Cânovas et al., 2020; Singh et al., 2020) . Emphatic electric field technology, which has the ability to kill microorganisms without causing undesirable changes in organoleptic properties in foods, consists of applying a short-term, high-voltage electricity to the food placed between 2 electrodes. In recent years, there are studies on the use of emphatic electric field technology in meat products (Bhat et al., 2019; Dong et al., 2020; Ghosh et al., 2020). Cold plasma technology is considered as a new application with a wide spectrum of activity against foodborne pathogens of interest to the meat industry. This technology uses reactive oxygen-nitrogen species, ultraviolet (UV) radiation, and causes deterioration in the cell membranes and DNA structure of microorganisms, allowing microbial growth to be controlled. In addition, it has been shown in some studies that cold plasma application can be an alternative to the production of meat products with reduced nitrite content (Lee et al., 2017; Jo et al., 2020). Ultrasound technology, which can be used to increase yield and water holding capacity and improve texture in meat, inactivates the cell walls of microorganisms due to cavitation created by sound waves ranging from 20 kHz-100 MHz (Alarcon-Rojo et al., 2019). Ohmic heating, which is included in thermal food technologies, is based on the process of heating the product by passing an alternating electric current through the food (Singh et al., 2020). These alternative innovative technologies are expected to replace traditional food processing technologies in the future due to the innovative perspective they bring to the production of “clean” labeled food products with high quality and low carbon footprint in the food industry.

The packages, which facilitate the storage and transportation of meat and meat products, also serve purposes such as extending the shelf life of the product, preserving its quality characteristics, providing information to the consumer with the label on it, and facilitating the commercialization of the product by giving it a remarkable feature. According to the report prepared by Plastics Europe, 39.9% of the 62 million tons of plastic produced in Europe in 2018 was used as a raw material source in the packaging industry (Anonymous, 2019a). Today, with the integration of the concept of sustainability into every stage of production, it has become imperative to prevent environmental pollution caused by fossil-based packaging wastes, which are not biodegradable, which are very difficult and costly to recycle. The focus is on the biodegradation or recycling capability of packaging materials with improved functional properties that provide long shelf life and ease of use. In this context, it is important to expand the use of biodegradable or edible packaging materials in the meat sector.

3 Protein sources can be an alternative to meat production

Diversification of protein sources, which can be an alternative to animal protein, can reduce the demand for traditional meat production and offer a solution to eliminate the negative effects of the livestock sector. For this purpose, researches on alternative protein sources such as meat analogues, artificial meat and insect protein are increasingly continuing. Studies are still being carried out to ensure that the products developed can be equivalent to the characteristics of traditionally produced meat in terms of nutritional value and sensory properties, and to reach the pleasure from traditional meat.

3.1 Artificial meat production

One of the alternative applications that emerged in order to prevent the negative environmental effects of traditional meat production is artificial meat, also called "in vitro meat", "culture meat" or "clean meat", produced from animal stem cells in a culture medium by cellular farming methods without slaughtering animals production (Bryant and Barnett, 2018; Broad, 2020). First introduced in 2013 with hamburger patties produced using cultured meat, artificial meat was born as a promising solution to reduce the environmental stress caused by animal husbandry (Fernandes et al., 2019).

Artificial meat is based on the principle of developing stem cells obtained from the muscle tissue of donor animals on the scaffold using appropriate media in a temperature and humidity controlled bioreactor (Post, 2012; Fernandes et al., 2019; Zhang et al., 2020a). In order for artificial meat produced under laboratory conditions to be consumed as a reliable and sustainable alternative, it must be able to imitate the characteristics of traditional meat such as appearance, smell, texture and taste. Although all necessary technologies have been developed to create skeletal muscle and adipose tissue, this is a challenging process (Melzener et al., 2020).

Today, artificial meat, which cannot be industrially produced, has difficulties to overcome such as diversifying the development environment of muscle tissue, optimizing production conditions and making the whole process financially viable (Bonny et al., 2015). Arguing that the production of the scaffold, which has a structure consisting of mammalian components on which muscle cells can multiply and differentiate, from animal components is incompatible with sustainability, Orellana et al. (2020) have produced a new scaffold in an edible film structure whose main components are salmon gelatin, alginate and agarose, which can be produced sustainably without being dependent on mammalian components. Acevedo et al. (2018) have developed micro molds that can provide the production of scaffolds in the form of edible films on which muscle cells can proliferate, in their studies to shorten the production time of artificial meat. Thanks to the scaffolds produced with these micro molds, the doubling time of muscle cells has been reduced to 18 hours.

Bodiou et al. (2020) modified microcarriers, which are widely used in medicine, for the first time in such a way that they can stimulate the development of muscle stem cells. Thus, it was possible to shorten the production time of artificial meat by accelerating the development of cell culture. Xueliang et al. (2020) studied bioreactors, which are defined as a temperature-controlled environment that will enable the development of artificial meat in the production phase. Thanks to the new type of air-lift bioreactor developed, it was concluded that with a single 300 m^3 reactor, the meat needs of 75,000 families can be met with artificial meat. There are also studies on artificial meat production with 3D bioprinters in order to reduce production costs and increase the availability of artificial meat (Dick et al., 2019; Handral et al., 2020). All these studies show that large-scale industrial production of artificial meat under sustainable conditions can be realized in the future.

Although there is uncertainty about its environmental impact, as artificial meat has not yet been commercialized except for a limited number of examples, it is predicted that it will have a lower environmental impact than meat produced on conventional farms, according to the researchers. Tuomisto and Mattos (2011) conducted a life cycle assessment (LCA) to evaluate the possible environmental effects of large-scale artificial meat production, in order to produce 1000 kg of artificial meat, 26.33 g of energy, 367-521 m3 of water, 190-230 m2 of water. They determined that land is needed and 1900-2240 kg CO2 equivalent greenhouse gas emission is spread to the environment. It has been observed that these amounts calculated for artificial meat production are quite low when compared to the environmental effects of traditionally produced meat in Europe (Tuomisto and Mattos, 2011). In another study by Tuomisto and Roy (2012), it was predicted that if the traditional meat produced in Europe was replaced by artificial meat, greenhouse gas production would decrease by 98.8%, land use by 99.7% and water use by 94% compared to current meat production.

In addition to its positive environmental effects, since the conditions during the production of artificial meat can be controlled, it will be possible to regulate the fat composition in the meat composition and improve its quality. Thus, it will be possible to prevent cardiovascular diseases that may occur as a result of meat consumption, and to produce functional meat by incorporating nutritional elements such as vitamins that can have an advantageous effect on health (Korhonen, 2002; Post, 2012). In addition, toxic compounds such as pesticides, arsenic, dioxins, health concerns associated with traditional meat, high price, safety of food hormones and risks of exposure to antibiotics, real meat expected during consumption will decrease (Bryant and Barnett, 2018). It has been seen that they take it because of their reservations about the issues such as the taste cannot be provided.

According to the survey studies, those who gave a positive opinion about the artificial meat consumption, which is thought to be inevitable, according to the survey studies, gave this decision, the consumer survey studies carried out on animal welfare, reducing environmental stress and some of them are given in Table 1. In these studies, individuals who refrain from consuming artificial meat on the necessity of sustainability stated that they took this decision because of their anxieties, due to their personal concerns and unnatural structure (Bryant & Barnett, 2018).

Table 1. Selected consumer surveys on artificial meat consumption by country.

Country / Number of Participants	Statement Made in the Questionnaire	Featured Negative Concepts	Positive	Source
Brazil / 626 participants	Information was provided with an explanatory video about artificial meat.	Animal welfare and environmental protection	Affordability. ethical concern. The Lack of research	(Valente et al., 2019)
Italy / 525 participants	The production method of artificial meat was mentioned; data from a university study were used to prove that artificial meat production is more efficient; The term “real meat” was used to describe the similarity of artificial meat with traditional meat.	Animal welfare. Food safety. The necessity of protecting the environment. Sustainability	Flavor Nutrition Food safety	(Mancini and Antonioli, 2019)
USA / 480 participants	It has been mentioned about the production method of cultured meat, its taste and nutrition similar to real meat; Expressions such as “clean meat”, “in vitro meat”, “culture meat” were used.	Flavor Safety	Cost	(Bryant and Dillard, 2019)

 https://doi.org/10.1051/e3sconf/202337602021

Dominican Republic, Spain / 401 participants	Participants were not informed.	The necessity of protecting the environment. Animal welfare and Nutrition	Food safety Price Flavor	(Gomez-Luciano et al., 2019)
Switzerland / 313 participants	Information was given on the production methods of genetically modified meat/fish, edible coating/films, artificial meat/milk and synthetic food additives.	Nutrition	Unnatural structure	(Egolf et al., 2019)
Germany / 713 participants	The production method of artificial meat is explained; it is stated that it contributes to animal welfare and that it has not yet taken place in supermarkets or butchers; While making definitions, names such as “in vitro meat”, “synthetic meat” and “culture meat” were used.	Animal welfare and Environmental effects	Unnatural structure(Price)	(Weinrich et al., 2020)
China / 1004 participants	The production of artificial meat, its benefits on health and the positive environmental effects it will provide are mentioned.	The necessity of protecting the environment	Taste Nutrition Food Safetiy Health	(Zhang et al., 2020b)
The Netherlands / 193 participants	It has been mentioned about the negative environmental effects caused by the livestock sector, the production method of artificial meat, its safe for consumption, its nutritional value, taste, smell and appearance similar to real meat.	The necessity of protecting the environment. Animal welfare. Flavor. Food safety	Price Feeling of being unfamiliar	(Rolland et al., 2020)

3.2 Insect proteins

Consumable insects, which have attracted attention in recent years, offer an alternative solution in meeting the increasing demand for protein sources, which are essential for the continuity of life, in sustainable ways. According to the 2015/2283 regulation of the European Food Parliament and Council, edible insects have become a food as of January 1, 2018 (Ademek et al., 2018). While people living in Western countries tend to meet their protein needs from foods of animal origin, they associate the consumption of insects as a protein source with poverty (Looy et al., 2014). While consumable insects are a vital food source in underdeveloped and developing countries, they also have an important place in food cultures (Tang et al., 2019). Although insect consumption, called entomophagy, is a new concept in North America and Europe, it is a habitual type of consumption for 2 billion people living in regions such as Africa, Asia and South America (Venne et al., 2017). Due to its high protein content and low production costs, many countries include Cricket (Acheta domesticus), honey bee (Apis mellifera), silkworm (Bombyx mori), caterpillar (Imbrasia belina), African palm worm Rhynchoporusphoenicis) and mealworm ('Tenebrio molitor). Insect breeding facilities are being established to produce six common commercial edible insect species (Tang et al., 2019). Insects produced in these facilities are euthanized by freeze-drying after physical cleaning. Freeze-dried insects can be packaged after this process or further processed such as roasting and grinding (Venne et al., 2017). The European Food Safety Authority (EFSA) recommends heat treatment for safety reasons, although it may cause aroma loss (Ademek et al., 2018).

According to the researches, the protein ratio in 100 grams of insects suitable for consumption as food varies between 7% and 48%, while this ratio is between 19% and 26% in beef. Insects, which are a rich source of protein in all life stages, are preferred because of their rich amino acid and fatty acid content while their immature forms are pupae and larvae. The crude protein content of a single insect is between 40-70% on a dry weight basis. The present protein contains adequate levels of essential amino acids such as isoleucine, leucine, lysine, phenyl alanine, threonine, valine, arginine, histidine and tyrosine (Tang et al., 2019). Insects have a high content of healthy fatty acids in their early life stages, but this rate drops below 20% when they reach adulthood. Saturated fatty acids and monounsaturated fatty acids usually make up more than 80% of all fats in larvae (Sales-Campos et al., 2013). Compared with the fat composition of beef, insects show promise for preventing cardiovascular diseases. In addition, insects are a source of vitamins that can provide vitamins A, B1, B12, C, D, E, and K, which are necessary for development and health, while they are also quite rich in terms of various minerals such as iron, magnesium, manganese, phosphorus, potassium, selenium, sodium and wealthy zinc. (Rumpold & Schluter, 2013; Kourimskä & Adämkovä, 2016). Non-fat insect powders, which have a very low consumer acceptance, especially in western countries, and provide a good alternative to milk-based protein powders used in packaged insects and sports nutrition, have taken their places on supermarket shelves (Venne et al., 2017). According to the survey studies conducted to explain the causes of neophobia about insect consumption despite high protein content, participants avoid consuming these products due to their prejudice, discontent and reluctance that insects may be a suitable food for consumption (Venne et al., 2017; Orsi et al., 2019; Poortvliet). , 2019; Woolf et al., 2019). The production of hybrid meat products by incorporating insect proteins into the formulation in proportions that will not cause a change in sensory properties is also among the alternative uses of insects. For this purpose, studies in which hybrid meat products produced by adding insect dust at different rates were examined in terms of physical, chemical and sensory properties are summarized in Table 2.

Table 2. Innovative studies on insect protein consumption.

Insect Protein / Product	Formulations	Findings	Source
Mealworm larva (Tenebrio molitor) and silkworm pupa (Bombyx mori) flours / Sausage	- Control: 60% lean pork, 20% ice, 20% back fat - Insect meal emulsions: 10% lean pork substitute with insect meal	By adding insect flours to the formulation, higher pH value, higher P, K, Ca, Mg, Zn, Mn and protein content, lower moisture content, harder structure, darker color formation	(Kim et al., 2016)

 https://doi.org/10.1051/e3sconf/202337602021

Silkworm pupa (Bombyx mori) powder / Meat pulp with Transglutaminase (TG)	Control: 85% pork, 15% water, 1.5% NaCl and 1% transglutaminase Groups with 5%, 10% and 15% silkworm pupa added	Groups with silkworm pupa added lower moisture, higher pH value, viscosity, protein and mineral content, darker color and a harder structure.	(Park et al., 2017)
Cricket (Acheta domesticus) meal / Meat emulsion	Control: 60% lean pork, 20% back fat, 20% ice, 2% salt Insect meal emulsions: 5% to 10% replacement of lean pork and/or back fat	Protein content and firmness increased with 5 and 10% cricket meal substitutions, and moisture content decreased with 10% cricket meal substitution.	(Kim et al., 2017)
Ground yellow mealworm (Tenebrio molitor L.) larvae / Frankfurter sausage	Check: 50% ham, 25% back fat, 25% ice Ground insect emulsions: 5%, 10%, 15%, 20%, 25%, 30% substitution with pork ham	Lower emulsion stability, moisture and fat content in sausages produced with the addition of yellow mealworms; higher pH value, protein and ash content; darker color Addition of up to 15% yellow mealybug did not have a negative effect on the product structure.	(Choi et al., 2017)
Concentrate of black soldier fly (Hermetia illucens) larva (BSFL) Viennese sausage'	Control: Lean pork, back fat, salt, spices, soy concentrate, starch, lecithin Emulsions containing insect concentrate: 34% BSFL, 31% BSFL and 28% BSFL	Similar ash and oil content in all samples Lower moisture and protein content in formulations with added BSFL The hardness of the BSFL groups decreased while maintaining the control hardness in cold storage.	(Bessa et al., 2019)
Ground worm larva (Zophobas morio larvae) (ZM) / Hybrid meat pulp	Insect model system: 100% ZM Meat model system: 100% pork ridge (DSE) Hybrid model system: 75% ZM + 25% DSE 50% ZM + 50% DSE 25% ZM + 75% DSE	Hybrid model systems have better viscoelastic properties compared to insect model systems; showed similar water holding capacity and textural properties.	(Scholliers et al., 2020)

Insect consumption as a protein source has environmental, economic and agricultural advantages besides nutrition (Gravel et al., 2020). The need for feed and water for growing insects is considerably less than for raising animals for meat production. Insects have a higher percentage of edible weight than animals raised for consumption. It has been reported that 80% of a cricket can be consumed, while 55% of a chicken and 40% of a cattle can be consumed. These rates indicate that edible insects are more productive. Also, the capacity of insects to produce offspring is considerably higher than conventional livestock. For example, a cricket can produce 1500 eggs in a month (Venne et al., 2017). Thanks to this rapid reproduction ability of insects, it may be possible to supply large amounts of protein in a short time, to meet the need for animal protein sources to some extent, and thus to reduce the environmental stress caused by the livestock sector.

Since edible insects have high nutritional value, their use as feed in livestock and aquaculture has also been the subject of research. When used in animal nutrition, food safety concerns due to the possibility of insects containing pathogen carriers or pesticide residues limit its use for this purpose. In scientific studies on this subject, 4 insect species, including black soldier fly, housefly, grasshopper and silkworm, attract attention. Black soldier fly (Hermitia illucens), which is one of these 4 insect species, differs from other insect species because it is resistant to insect diseases and its larvae are easy to produce (Stamer, 2015). Popova et al. (2020), the larvae of the Hermetia illucens species were used in chicken nutrition, and it was determined that the weights of chickens fed with larvae were higher. Protein, lauric acid and myristic acid contents of the meat obtained from chickens fed with larvae were found to be higher than the control group. Insect species such as Hermetia illucens, Musca domestica, Tenebrio molitor and Zophobas morio were mixed in different proportions to improve the amino acid and fatty acid profiles of fish feeds and increase their nutritional value (Nogales-Merida et al., 2019).

4 Conclusion

The reflection of the global trends affecting the whole world we live in, on the production chain of meat, which has been the main protein source in nutrition for centuries, has brought up sustainable production and consumption phenomena. Equipping the meat supply chain, which is thought to be progressing in an unsustainable direction today, with innovative green technologies from raw materials to the final product, in order to follow a vision that values animal welfare and human health, and creates an economic and less environmental impact, will be an important step for this sector to move into the future. In this context, producers should be encouraged to produce raw materials compatible with animal welfare by equipping traditional farms with smart technologies, and to use environmentally friendly innovative green technologies instead of existing technologies in the processing and preservation of the produced raw materials. The inclusion of genetically selected animal species with high carcass yield and resistant to diseases in the raw material production network raises some debates due to the negative effects of biodiversity and socio-cultural aspects, as well as the trend of returning to nature, which affects a large part of the society. The health effects of artificial meat, which is seen as an alternative protein source of the future with its structure that does not contain veterinary residues such as hormones, antibiotics, or contaminants that may pose a risk to public health, and large-scale production possibilities in quantities that will meet the needs of the world should be investigated. Consumption of insect proteins and meat analogues produced from vegetable proteins, which attract attention in some countries due to their high nutritional value and low cost advantages, is met with food neophobia, especially in western countries. In order to increase the acceptability of the diet with these alternative products, it is important to reflect the views and wishes of the consumers to the market. These innovative practices should be evaluated with an environmentally and nature-friendly approach that is compatible with food safety and legal regulations, taking into account the ethical concerns they create. On the other hand, the perception of technology and new ideas as an aid rather than a threat in superior society models, where the reflections of digitalization affecting the whole world have been seen in recent years, will facilitate the integration of these new practices into sustainable meat supply systems, and that future generations will have the same opportunities available today, It will help them establish a safe lifestyle.

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