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Plant-Based Meat: A Comprehensive Review of Formulation, Processing, Health Implications and Consumer Acceptance

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Abstract: The high demand for plant-based products due to their potential health and environmental benefits has boosted the popularity of meat substitutes known as meat analogs. This review will discuss the rise and acceptance of these plantbased meat alternatives that have been of interest for several decades and have become prominent recently. The market for these alternatives is growing substantially. This paper aims to look at current research on meat analogs, pinpoint future research areas, discuss the reasons behind the move towards meat alternative consumption because of health and environmental issues, identify possible sources and necessary technologies for developing meat analogs, describe physical characteristics of meat substitutes, discuss ingredient functionality in creating plant-based meats, look into what happens to these products within our digestive system and summarize consumer's reactions along with challenges, the meat industry faces. The discussion will take into account factors such as market growth drivers, formulation approaches, advantages and disadvantages of traditional versus modern processing methods, safety and nutritional elements along with consumer's viewpoints. The paper outlines industry achievements, problems faced, and potential future directions to cater to the increasing demands of health-focused consumers while addressing environmental worries. There is ample indication that conventional methods used in making animal produce raise key health fears along with noticeable negative impacts on the environment forming a strong motivation to move towards creating a variety of alternative meats through using methods that enhance proper elements necessary in this process.

Keywords: Plant based meat; Meat analogs; Alternative protein formulation; Sustainability; Plant based protein

Graphical abstract



Aim:To explore the formulation, processing techniques, health implications and consumer's acceptance of plant-based meat products.

Introduction: Meat is key to mankind's daily nutritional needs, providing essential nutrients like protein, fats, vitamins, and minerals. There are predictions that the global meat market will grow annually by 7.35% from 2020 until 2025 (Boukid et al., 2020). There is a growing focus on sustainability among food producers and consumers because it boosts knowledge and awareness (Grunert et al., 2014). The focus on sustainability covers ecological, social, and economic grounds with a growing recognition of a fourth aspect of health (Curtain et al., 2019). Since the year 2015, over 4400 plant-based meat substitute products have come up all around the globe with an aim to match the taste, texture and look of meat derived from animals (Curtain et al., 2019). On days when one opts to eat minimal meat servings, they can choose alternatives such as fish, cheese or eggs which are rich in protein, but they often lack the sensory delight associated with eating meat (Nezlek et al., 2022). This has given rise to plant-based alternatives that replicate animal derived products (Szenderak et al., 2022) while remaining primarily crafted from plant proteins in order to closely mimic the sensory attributes of animal meats (Swing et al., 2021). Lack of familiarity combined with less sensory appeal proved to be hurdles while adopting meat substitutes (Hoek et al., 2011; Lea et al., 2003) Nevertheless there's been advocacy for plant-based alternatives citing environmental benefit potential downfalls tied to common

production processes for conventional meats. Also, these were created with a goal of attracting consumers who are not vegetarians by easily integrating into existing supply chains.

Increased agreement among scientists' states that making significant changes toward diets that focus mainly on plants especially in countries where it's common to consume large amounts of meat is absolutely necessary to meet climate change reduction objectives (Bajželj et al., 2014; Hedenus et al., 2014; Bryngelsson et al., 2016). Plant based diets, known as PBDs, are gaining popularity in Western countries (AlaeCarew et al., 2022). A concept known as the "meat paradox" shows that many individuals wish to eat meat but don't want it linked with moral issues or health and animal welfare problems (Buttler et al., 2018). There are a variety of food technologies set up to bridge these gaps between behaviours and attitudes on the backdrop of increasing demands for ecologically friendly or animal compassion-based foods. With both traditional meat production and consumption, more challenges emerge it is this that propels conversation on alternative meats in the context of food technology development (Specht et al., 2018; Hocquette, 2018).

Market Trends and Growth Drivers

There is a significant growth in the market for meat analogue products (Smetana et al., 2023). states that this market amounted to USD 1.6 billion globally in 2019. Projections show that the said market would hit USD 3.5 billion worth by 2026, an indication of a remarkable compounded annual growth rate of 12.0% during the foretold season (Boukid et al., 2020).92% of participants in the United States who reported consuming proteins acknowledged they came from animals and 72% also took something made from plants (Messina et al., 2023). According to this trend, it showed that 50% of respondents didn't follow any specific diet plan whereas only 11% among them followed diets based on plants. Between 66% to 76% of respondents constituted the largest group of omnivores. Fewer than 27% classified themselves as vegetarian, vegan or pescetarian. This trend was observed in the US as well as in unspecified nationalities by (Szenderak et al., 2022). The drive toward plant-based meat has been growing steadily with demands supported by consumers' beliefs regarding health, environment and animal abuse (Bryant et al., 2022; Cardello et al., 2022) explores the growth of the market, the preferences of consumers and the impact of media and marketing in promoting products made from plant proteins. However, these have been made more difficult because it is expected that there would be an increased demand in animal protein which should lead to even more pressure being put on land resources because there will be a need for more animal feeds. Forests, wetlands and natural grasslands are therefore increasingly converted to agricultural land (Henchion et al., 2017). It also has negative consequences for things such as greenhouse gas emissions and biodiversity, as well as multiple vital ecosystem services (Zanten et al., 2016). Previous study showed that individuals who consume meat regularly often prefer beef over plant-based choices in contrast to those who claim to be vegan, practice partial vegetarianism or flexible non-vegetarian diet as was posited by (Tonser et al., 2023).

Plant-based meat substitutes labelling is disputed among stakeholders; with some industry players opposing the use of the term "meat" as well as proposing legislation to bar "misleading advertising" for "sham meat". Nonetheless, there are those who think that there is no deception in labelling products purporting to be meat analogs derived from plants so long as it is stated on the package's surface that they contain plants (Silverman et al., 2020). A player in this market could benefit greatly from owning intellectual property worth hundreds of millions or even billions of dollars due to the fact that it is anticipated that the market will experience a compound annual growth rate (CAGR) of 17% from 2019 to 2024 (Tyndall et al., 2024) and has a young technology base. Much is left to be discovered in the mission for feeding the world sustainably.

Formulation Strategies

For choosing ingredients, ensuring this requires consideration of several factors, such as affordability and wide availability, favourable biocompatibility, and most importantly, exceptional functionalities (Sun et al., 2021). According to Guy's categorization method, functional materials can be gualified into six roles: structure-forming, filling disperse-phase, plasticizing or lubricating, soluble solids, nucleating, colouring materials, flavouring ingredients. Similarly, a standard recipe use for meat analogue includes six components: water, proteins, flavourings, fat, binding agents, and colouring agents. Water accounts for the bulk of the ingredients at 50-80%, which is an indigenous plasticizer in processing meat analogue with respect to improving juiciness. This chapter brings forth those proteins and polysaccharide, their blends, make important factors in defining product identity and differentiation, as well as texture within the lines of the meat analogue products (Sun et al., 2021). This original globular structure of pulse proteins is modified into a fibrous one with highly ordered and extended proteins, giving a meat-like structure (Angelis et al., 2020). Concomitantly with the development of plant-based meat substitutes, many process-ing methods have emerged or been adopted for their processing, either mimicking whole muscle structures or restructured forms but always with the objective of mimic-ry of the target texture. Among them, one of the oldest and very well studied techniques is thermo-extrusion, which finds broad application (Boguvea et al., 2023). However, lately, many other methods have been proposed in order to create analogues of muscle fibres (Sha et al., 2020). Such methods are wet spinning, electrospinning, and conical shear.

The mechanisms of operation and the unique morphological and structural features that such fibres obtain from all these types of methods have been very well expounded previously by (Dekkers et al., 2018). Several additives have

been proposed before to extend the range of raw materials for producing meat alternatives without compromising the excellent quality of the final product (Andreani et al., 2023). Examples include the Namely colorants: leghaemoglobin, red beets, and red cabbage, and flavourings: herbs and spices. These additives help replicate the colour and flavour profiles of the meat, while concealing any off-flavour or bean-like tastes some particular legume proteins might have (Rai et al., 2023). Moreover, various fats and oils, such as coconut oil, butter, sunflower oil, canola oil, and sesame oil, are used to give the attributes of juiciness and tenderness to meat-like products (Andreani et al., 2023). However, nowadays it is becoming a trend to use binding agents like oleogels, starches, hydrocolloids, or even fibres in place of these fats (Zahari et al., 2022).

Nutritional Implications

Moderate levels of meat consumption can contribute to health benefits and food security and dietary quality, especially for food-insecure people who are poorly resourced (Szenderak et al., 2022). There was observed a high content of some major elements in both plant-based and meat-based burgers, like Ca, K, Mg, Na, P, and S. The same levels were registered for the content of Na, S, and Si while lower for Zn in plant-based burgers compared to meat-based ones (De Marchi et al., 2021). No marked differences were seen for the total protein and fat content of these extracts, probably due to the presence of coconut oil as bone of the ingredients. The examination of amino acid composition, on the other hand, showed that there were marked differences in five out of the eighteen amino acids in total (Mat et al., 2022). Briefly, vegetable burgers showed a much higher reduction in cholesterol content; the median value was 3.98 mg/100 g in the raw product, while respective meat-based product values were at 50.60 mg/100 g, as (Szenderak et al., 2022). The meat substitutes available ranged from 210 mg to 900 mg of sodium in cold cuts and other types, making them indicative of a high level of sodium content. Excessive sodium intake is one of the major public health concerns these days, and it is being consumed extensively in industrially processed products, as in the case of plant-based meat alternatives (Romao et al., 2023). In trying to introduce the chewiness and elasticitylike in ABMsto modern PBMAs, most of them are using isolated proteins derived from legumes and oilseed and cereal grains. Apart from these, they add refined fats and oils resulting from sources such as coconuts, cocoa fruit, sunflower seeds, and rapeseed to enhance the mouthfeel and raised sensory experience (Swing et al., 2021).

On the other hand, while consumer demands for "clean labels" have brought questions to the forefront regarding the use of some binder and gum ingredients in plant-based alternatives, research indicates that methylcellulose and guar gum do contribute to the same cholesterol-lowering and glucoselowering benefits associated with other dietary fibers (Mudgil et al., 2014; Kuczora, 2015; Bohrer, 2019). It is feared that the promotion of reduced intake of specific foods might foster an increase in eating disorder-like behaviours within specific demographic subgroups (Scaglioni et al., 2018). Another disadvantage with regards to focusing solely on proteins is that this excludes some complexities regarding the presence of antinutritional factors, such as phytates and oxalates, frequently occurring in plants and interfering with the protein absorption rate (Munialo and Andrei, 2023). Therefore, an effort that would be less risky for young people is to focus more on increasing the consumption of certain types of food. For example, some researchers have reported that programs undertaken to prevent obesity in adolescents sometimes promote eating disorder behaviour (O'Dea et al., 2005).

Safety Consideration: In a randomized crossover trial, investigators assessed the similar effects of plant-based and meat-based high-protein diets on gutpeptide hormones and subjective appetite responses (Neacsu et al., 2014). However, when individuals ingested a plant-based meal standardized for energy and macronutrients with the meat-based meal, they found an elevation in peptide YY, glucagon-like peptide 1, and amylin, with increased thalamus perfusion (Kahleova et al., 2021; Klementova et al., 2019). The rise of plant-based meat has, however, been perceived as a threat by some people and groups, especially those whose livelihoods or ranching economies depend on animal husbandry, despite the fact that the production of PBM does not naturally cause a threat to the long-term sustainable production of traditional animal meat (Van Loo et al., 2020; Santo et al., 2020). First, to really reduce the negative impact on animal welfare worldwide exerted by traditional meat production, this would be particularly associated with countries characterized by intensive farming conditions and with the slaughter process itself (Heidemann et al., 2020). A benefit is doled out every time traditional meat is replaced by another alternative product. The second reason is based on the idea that, upon resolving the "meat paradox," fewer people would become desensitized to the mistreatment and abuse of animals. The "meat paradox," as described by Loughnan et al., (2014) pertains to the phenomenon of two attitudes that clearly contradict each other, where, on one hand, humans condemn the empathy of harm toward animals and, on the other hand, continue enjoying meat consumption. Some health experts have expressed concerns regarding the use of carrageenan as an additive in foods. In fact, this polysaccharide is derived from seaweed and sometimes added into processed meat alternatives as a thickener or gelling and stabilizing agent (Senadheera et al., 2023). Some have even linked the consumption of carrageenan to gastrointestinal inflammation, changes in intestinal microflora, and irritable bowel syndrome, while others have gone as far as linking it to the incidence of colon cancer (Bixler et al., 2017). Phytochemicals, abundant in plant meals, have been shown to have the capacity for preventing carcinogenesis by decreasing DNA damage and interfering with oxidative stress signalling pathways (Chikaraet

al., 2018). In general, chemicals, be they hormones, pesticides, or food technology, are closely associated with food safety concerns that may have an immediate impact on people's health (Hever et al., 2017). Concerns about food safety in this study are, therefore, categorized into two classes: mistrust in biotechnology, which is a negative cognitive factor, and drug-free cleanliness, which is a positive cognitive factor (Sharma et al., 2018).

Consumer Acceptance and Perception

Principally speaking, the rise of meat substitutes has been very strong in the Western market; in 2020, it recorded the highest sales of USD 4.2 billion with 24% growth. Consumer acceptance remains the big challenge in the meat substitute categories. In general, in unfamiliar food categories, like meat alternatives, little or no research is conducted on consumer preference and acceptance. Further research in novel food technologies is necessary because their success relies on consumer acceptance (Szenderak et al., 2022). It was evident in a 2019 survey of US adults that 86% of the population reported taste as the most basic driver of purchase decisions, which supports the essence that an unpleasant and unexpected taste is likely to be a barrier to acceptance. An interesting factor is that consumers who are not vegetarians are also slow to consume the meat analogues on the basis that if they choose healthier options, the taste may not be as fulfilling (Fiorentini et al., 2020). As a result of the stigma associated with, for example, ugly fruits and vegetables, recent research has shown that labelling them as such actually increases demand. This labelling strategy differs from the more common approach of emphasizing scientifically measurable traits like "low fat" or "high vitamins," together with touting natural preservation with claims such as "no additives" or "unprocessed" (Jahn et al., 2021). By definition, millennials, also called Generation Y, refer to environmentally conscious young adults born in the 1980s and 1990s. Studies on food sustainability often target them because of their heightened ability with regards to environmental issues (Ogiemwony et al., 2022). As Millennials are the parents of young children, they also become major players in the formation of food consumption habits (Knaapila et al., 2022). Although eating meat alternatives alone obtained the highest acceptance scores, their appropriateness for occasions like a Sunday family gathering or dining at a restaurant or business meeting or even a barbecue party was ranked low (Szenderak et al., 2022). Again, eating patterns of individuals are expected to follow the eating behaviour of their social group (Higgs et al., 2016). It simply means that in more formal situations and circumstances where, according to them, a certain peer pressure is likely to prevail, one might not want to attract attention or are afraid of being judged by the food decisions they make (Hartmann et al., 2018; Yantcheva and Brindal, 2013).

Conclusion

It turns out to be not only a viable alternative to traditional meat products but also a sustainable one. Of course, this is instigated by growing consumer awareness and demand for healthier and environmentally friendlier options. This paper, therefore, reviews the current knowledge on the plant-based meat industry in respect to formulation, processing, nutritional considerations, safety, and consumer preference. Addressing the difficulties and leveraging the innovations that have come about during its evolution set a base for what the outlook of plantbased meat will be. The plant-based meat substitutes represent a big deal for the environment and climate change. Almost everyone tends to eat a pretty sizable amount of meat, while others-one-third or less are vegetarians, vegans, or pescatarians. Those who usually eat a large quantity of meat will be very much less likely to try plant-based alternatives at all. In general, willingness to try these novel foods exists; some people, though, do find this rather weird. The ones with higher incomes are more likely to make a purchase, and there are sectors that are willing to pay a premium. However, plant-based meat alternatives can be costlier than regular meat. People do care about the environment, but that is not the reason for the choice of food they consume. Some people believe that plantbased foods are healthier than others. This may not be so in some kinds of plantbased food. Feeling and tasting like real meat is an important aspect of plantbased foods, so it is good that they are similar. Probably a more central point in promoting these foods could be giving information on how it benefits the environment and health. But they must also be affordable. Even with these barriers, a large potential market for plant-based meat alternates exists with growing concerns about the environment and health. It doesn't mean that everything in your diet is going to change, but you move a bit toward better eating.

References

- Alae-Carew, C., Green, R., Stewart, C., Cook, B., Dangour, A. D. andScheelbeek, P. F(2022). Science of the Total Environment, The role of plant-based alternative foods in sustainable and healthy food systems: Consumption trends in the UK. Volume 807: Page. 151041.
- Andreani, G., Sogari, G., Marti, A., Froldi, F., Dagevos, H. and Martini, D (2023). Nutrients, Plant-based meat alternatives: technological, nutritional, environmental, market, and social challenges and opportunities. Volume 1 Number 2: Page. 452.
- Bajželj, B., Richards, K. S., Allwood, J. M., Smith, P., Dennis, J. S., Curmi, E. and Gilligan, C.A(2014). Nature Climate Change, Importance of fooddemand management for climate mitigation. Volume 4 Number 10: page. 924-929.

- 4. Bixler, H. J (2017). Journal of Applied Phycology,"The carrageenan controversy." Volume 29: Page. 2201–2207.
- 5. Bogueva, D. andMcClements, D. J (2022). Food Safety Magazine, Safety and Nutritional Risks Associated with Plant-Based Meat Alternatives.
- Bogueva, D. andMcClements, D. J (2023). Sustainability, Safety and Nutritional Risks Associated with Plant-Based Meat Alternatives. Volume 15 Number 19: Page. 14336.
- Bohrer, B. M (2019). Food Science and Human Wellness, An investigation of the formulation and nutritional composition of modern meat analogue products.Volume 8 Number 4: Page. 320-329.
- 8. Boukid, F (2020). European Food Research and Technology, Plant-based meat analogues: from niche mainstream. Page. 297-308.
- 9. Bryant, C. J (2022). Future Foods, Plant-based animal product alternatives are healthier and more environmentally sustainable than animal products.Volume 6: Page. 100174.
- 10. Bryngelsson, D., Wirsenius, S., Hedenus, F. andSonesson, U (2016). Food Policy, How can the EU climate targets be met? A combined analysis of technological and demand-side changes in food and agriculture. Volume 59: Page. 152-164.
- 11.Buttlar, B. and Walther, E (2018). Appetite, Measuring the meat paradox: How ambivalence towards meat influences moral disengagement. Volume 128, Page.152-158;
- Cardello, A. V., Llobell, F., Giacalone, D., Chheang, S. L. and Jaeger, S. R (2022). Foods, Consumer preference segments for plant-based foods: the role of product category. Volume 11 Number 19: Page. 3059.
- 13. Chikara, S., Nagaprashantha, L. D., Singhal, J., Horne, D., Awasthi, S. andSinghal, S. S (2018). Cancer Letters, Oxidative stress and dietary phytochemicals: Role in cancer chemoprevention and treatment. Volume 413: Page. 122-134.
- 14. Choudhury, D., Singh, S., Seah, J. S. H., Yeo, D. C. L. and Tan, L. P (2020).Trends in Plant Science, Commercialization of plant-based meat alternatives. Volume 25 Number 11: Page. 1055-1058.
- 15. Curtain, F. and Grafenauer, S (2019). Nutrients, Plant-based meat substitutes in the flexitarian age: An audit of products supermarket shelves. Volume 11 Number 11: Page. 2603.
- 16. De Angelis, D., Kaleda, A., Pasqualone, A., Vaikma, H., Tamm, M., Tammik, M. L. andSummo, C (2020). Foods, Physicochemical and sensorial evaluation of meat analogues produced from dry-fractionated pea and oat proteins. Volume 9 Number 12: Page. 1754.
- De Marchi, M., Costa, A., Pozza, M., Goi, A. andManuelian, C. L (2021).Scientific reports, Detailed characterization of plant-based burgers. Volume 11 Number 1: Page. 2049.

- Dekkers, B. L., Boom, R. M. and van der Goot, A. J (2018). Trends in Food Science & Technology, Structuring processes for meat analogues. Volume 81: Page. 25-36.
- 19. Fiorentini, M., Kinchala, A. J. andNolden, A. A (2020). Foods, Role of sensory evaluation in consumer acceptance of plant-based meat analogs and meat extenders: A scoping review. Volume 9 Number 9; Page. 1334.
- 20. Grunert, K. G., Hieke, S. and Wills, J (2014). Food policy. Sustainability, labels on food products: Consumer motivation, understanding, and use. Volume 44: Page. 177-189.
- 21. Hagmann, D., Siegrist, M. and Hartmann, C (2019). Public Health Nutrition, Meat avoidance: Motives, alternative proteins and diet quality in a sample of Swiss consumers. Volume 22 Number 13: Page. 2448-2459.
- 22. Hartmann, C., Furtwaengler, P. andSiegrist, M. (2022). Food Quality and Preference, Consumers' evaluation of the environmental friendliness, healthiness and naturalness of meat, meat substitutes, and other proteinrich foods. Volume 97: Page. 104486.
- 23. Hartmann, C., Keller, C. and Siegrist, M (2016). Appetite, Compensatory beliefs, nutrition knowledge, and eating styles of users and non-users of meal replacement products. Volume 105 Page.775-781.
- 24. Hartmann, C., Ruby, M. B., Schmidt, P. andSiegrist, M (2018). Food Quality and Preference, Brave, health-conscious, and environmentally friendly: Positive impressions of insect food product consumers. Volume 68: Page. 64-71.
- 25. Hedenus, F., Wirsenius, S. and Johansson, D. J (2014). Climatic change, The importance of reduced meat and dairy consumption for meeting stringent climate change targets. Volume 124 Number 1: Page. 79-91.
- 26. Heidemann, M. S., Molento, C. F. M., Reis, G. G. and Phillips, C. J. C (2020). Frontiers in Psychology, Uncoupling meat from animal slaughter and its impacts on human-animal relationships.Volume 11: Page. 1824.
- 27. Hever, J. andCronise, R. J (2017). Journal of geriatric cardiology: JGC, Plant-based nutrition for healthcare professionals: implementing diet as a primary modality in the prevention and treatment of chronic disease. Volume 14 Number 5: Page. 355.
- 28. Higgs, S. and Ruddock, H (2020). Handbook of eating and drinking: Interdisciplinary perspectives, Social influences on eating. Page. 277-291.
- 29. Hoek, A. C., Luning, P. A., Weijzen, P., Engels, W., Kok, F. J. and De Graaf, C (2011). Appetite, Replacement of meat-by-meat substitutes: A survey on person-and product-related factors in consumer acceptance. Volume 56 Number 3: Page. 662-673.
- 30. Hocquette, J. F (2016). Meat science, Is in vitro meat the solution for the future? Volume 120: Page. 167-176.

- 31. Hwang, J., You, J., Moon, J. andJeong, J (2020). Sustainability, Factors affecting consumers' alternative meats buying intentions: Plant-based meat alternative and cultured meat. Volume 12 Number 14: Page. 5662.
- 32. Jahn, S., Furchheim, P. andStrassner, A. N (2021). Sustainability, Plantbased meat alternatives; motivational adoption barriers and solution. Volume 13 Number 23: Page. 13271.
- 33. Joyce, A., Hallett, J., Hannelly, T. and Carey, G (2014). Energy and Emission Control Technologies, The impact of nutritional choices on global warming and policy implications: examining the link between dietary choices and greenhouse gas emissions.Page. 33-43.
- 34. Kahleova, H., Tintera, J., Thieme, L., Veleba, J., Klementova, M., Kudlackova, M.andPelikanova, T (2021). Clinical Nutrition, A plant-based meal affects thalamus perfusion differently than an energy-and macronutrient-matched conventional meal in men with type 2 diabetes, overweight/obese, and healthy men: A three-group randomized crossover study. Volume 40 Number 4: Page. 1822-1833.
- 35. Klementova, M., Thieme, L., Haluzik, M., Pavlovicova, R., Hill, M., Pelikanova, T.andKahleova, H (2019). Nutrients, A plant-based meal increases gastrointestinal hormones and satiety more than an energy-and macronutrient-matched processed-meat meal in T2D, obese, and healthy men: a three-group randomized crossover study. Volume 11 Number 1. Page.157.
- 36. Kumar, P., Chatli, M. K., Mehta, N., Singh, P., Malav, O. P., Verma, A. K. and Kumar, D (2017). Critical reviews in food science and nutrition, Meat analogues: Health promising sustainable meat substitutes.Volume 57 Number 5: Page. 923-932.
- 37. Kyriakopoulou, K., Dekkers, B. and van der Goot, A. J (2019). Sustainable meat production and processing, Plant-based meat analogues.Page. 103-126.
- 38.Lynch, J.andPierrehumbert, R (2019). Frontiers in Sustainable Food Systems, Climate impacts of cultured meat and beef cattle. Volume 3: Page.5.
- 39. Mattick, C. S., Landis, A. E., Allenby, B. R. and Genovese, N. J (2015). Environmental science & technology, Anticipatory life cycle analysis of in vitro biomass cultivation for cultured meat production in the United States. Volume 49 Number 19: Page. 11941-11949.
- 40. Michel, F., Hartmann, C. and Siegrist, M (2021). Food Quality and Preference, Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. Volume 87:Page.104063.
- 41. Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J. C., Louzada, M. L. C., Rauber, F. and Jaime, P. C (2019). Public health nutrition, Ultra-processed foods: what they are and how to identify them.Volume 22 Number 5: Page. 936-941.

- 42. Neff, R. A., Edwards, D., Palmer, A., Ramsing, R., Righter, A. andWolfson, J (2018). Public health nutrition, Reducing meat consumption in the USA: a nationally representative survey of attitudes and behaviours. Volume21 Number 10: Page. 1835-1844.
- 43.Nordgren, A (2012). Journal of agricultural and environmental ethics, Ethical issues in mitigation of climate change: The option of reduced meat production and consumption. Volume 25 Number 4. Page. 563-584.
- 44. Onwezen, M. C., Bouwman, E. P., Reinders, M. J.andDagevos, H(2021). Appetite, A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat. Volume 159: Page. 105058.
- 45. Post, M(2014). An alternative animal protein source: cultured beef, Annals of the New York Academy of Sciences, Volume 1328 Number 1: Page. 29-33.
- 46. Post, M. J (2020). Meat Science, Cultured meat from stem cells: Challenges and prospects. Volume 9 Number 3: Page. 297-301.
- 47. Post, M. J (2021). Meat Science, Cultured meat from stem cells: Challenges and prospects. Volume 92 Number 3: Page. 297-301.
- 48. Richi, E. B., Baumer, B., Conrad, B., Darioli, R., Schmid, A. and Keller, U (2015). Health risks associated with meat consumption: A review of epidemiological studies, International Journal for Vitamin and Nutrition Research.Volume 85Number 1-2: Page. 70-78.
- 49. Santo, R. E., Kim, B. F., Goldman, S. E., Dutkiewicz, J., Biehl, E. M., Bloem, M. W. and Neff, R. A (2020). Frontiers in Sustainable Food Systems, Considering plant-based meat substitutes and cell-based meats: A public health and food systems perspective. Volume 4: Page.134.
- 50.Sarma, D., Gupta, V. and Sharma, G. D (2022). Critical Reviews in Food Science and Nutrition, Future of plant-based meat analogues:Challenges and prospects. Page.1-12.
- 51. Schaefer, G. O. and Savulescu, J (2014). Journal of Applied Philosophy, The ethics of producing in vitro meat. Volume 31 Number 2: Page. 188-202.
- 52. Sha, L. andXiong, Y. L (2020). Trends in Food Science & Technology, Plant protein-based alternatives of reconstructed meat: Science, technology, and challenges. Volume 102: Page. 51-61.
- 53. Siegrist, M. and Hartmann, C (2019). Appetite, Impact of sustainability perception on consumption of organic meat and meat substitutes. Volume 132: Page. 196-202.
- 54. Siegrist, M., Hartmann, C. and Keller, C (2020). Food quality and preference, Antecedents of food neophobia and its association with eating behaviour and food preferences. Volume 79: Page. 103750.
- 55. Siegrist, M., Visschers, V. H. and Hartmann, C (2015). Food quality and preference, Factors influencing changes in sustainability perception of

various food behaviours: Results of a longitudinal study. Volume 46:Page. 33-39.

- 56. Slade, P(2018). Consumer preferences for plant-based and cultured meat burgers, AppetiteIf you build it, will they eat it? Volume 125: Page. 428-437.
- 57. Smetana, S., Mathys, A., Knoch, A. and Heinz, V (2015). The International Journal of Life Cycle Assessment, Meat alternatives: life cycle assessment of most known meat substitutes. Volume 20: Page. 1254-1267.
- 58. Smith, T., Kelly, A., Ye, X., Beasley, S., Thomas, A. and Wakefield-Scurr, J (2022). International Journal of Food Science & Technology, Milk protein concentrate 80: Balancing food functionality and sustainability. Volume 57 Number 2: Page. 803-812.
- 59. Sosa, M. A. and Asseraf, Y (2023). Journal of Consumer Marketing, From rejection to attraction: consumer acceptance of plant-based meat alternatives.
- 60. Tso, R., Lim, A. J. and Forde, C. G (2021). Foods, A critical appraisal of the evidence supporting consumer motivations for alternative proteins. Volume 10 Number 1: Page. 24.
- 61.van der Weele, C. andDriessen, C (2013). Animals, Emerging profiles for cultured meat: ethics through and as design. Volume 3 Number 3: Page. 647-662.
- 62. Weele, C. V. D. andTramper, J (2014). Trends in Biotechnology, Cultured meat: Every village its own factory? Volume 32 Number 6: Page. 294-296.
- 63. Wilks, M., Hornsey, M. J., Bloom, P. and Attwood, S (2021). Frontiers in Sustainable Food Systems, Are clean meat startups fighting a fair fight? Investigating the coverage of clean meat in the media. Volume 5: Page. 613313.
- 64. Wilks, M. and Phillips, C. J (2017). PloS one, Attitudes to in vitro meat: A survey of potential consumers in the United States. Volume 12 Number 2: Page. e0171904.
- 65. Witte, S. andKlümper, F(2022). International Journal of Environmental Research and Public Health, Life cycle assessment of plant-based meat analogues: The ecological benefits of meat alternatives. Volume 19 Number 2: Page. 743.
- 66. Wozniak, H., Larpin, C., Mottet, A. andPeterli, R (2021). American Journal of Lifestyle Medicine, Lifestyle modification and cardiovascular risk reduction in the obese: beyond pharmacotherapy. Volume 15 Number 4 Page. 448-459.
- 67. Xu, L., Cai, C. X. and Chen, Z (2020). Journal of Food Science, Advances in the development of plant-based meat alternatives. Volume 85 Number 8: Page. 2269-2280.
- 68. Yarimoglu, E. andGunay, T(2020). Business Strategy and the Environment, The extended theory of planned behaviour in Turkish customers' intentions to visit green hotels. Volume 29 Number 3: Page. 1097-1108.

- 69. Zhang, M., Li, L. andBai, J(2020). Journal of Food Science, Plant-based meat alternatives: sensory attributes and their impact on consumer preference. Volume 85 Number 12: Page. 4157-4166.
- 70. Zhao, W., Zeng, Y., Rao, G., Liang, G. and Liu, X (2022). Critical Reviews in Food Science and Nutrition, Antioxidant potential of plant-based meat alternatives: A systematic review and meta-analysis. Volume 62 Number 9: Page. 2495-2514.