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Planetary health and the promises of plant-based meat from a sub-Saharan African perspective: A review

Omamuyovwi Gbejewoh[a], Jeannine Marais[a], Sara Wilhelmina Erasmus[b,*]

[a] Department of Food Science, Faculty of AgriSciences, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa
[b] Food Quality & Design Group, Wageningen University & Research, P.O. Box 17, 6700 AA, Wageningen, The Netherlands

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ABSTRACT

Increasing population and disposable income has caused a change in the sub-Saharan African diet to more animal sources of protein, especially in the urban areas. Planetary health concerns are bound to be more prominent with this increased consumption. Meat alternatives has emerged as a potential alternative. However, its research in the continent is lacking despite the projected increase in meat consumption in the coming years This review aims to address this gap by examining the available literature regarding plant-based meat alternatives production and consumption. This review found that meat alternatives are similar in nutrient composition to meat, although differences in essential nutrients warrants caution. Furthermore, even though meat alternatives are less environmentally demanding, the potential health concerns demand further study. The review also found that meat is eaten for more than just physiological needs and it has socio-cultural connotations, especially in sub-Saharan Africa (SSA). Consequently, to encourage consumers to substitute their traditional meat, these barriers need to be adequately researched. Regardless, there are various opportunities for plant-based meat adoption; circumstantially evidenced by the increasing demand of vegan and vegetarian products in some parts of SSA. Yet, large-scale adoption of meat alternatives is stymied by limited consumer research in SSA.

Introduction

In the coming decades, the population of Africa and specifically sub-Saharan Africa (SSA) is expected to double to about 2.5 billion people in 2050, with over 60% of this expected population residing in urban areas. At the same time, barring unforeseen circumstances, the gross domestic product (GDP), income and purchasing power of these countries and people is also expected to increase ([57]). While the current diet of a significant part of the population of SSA is mainly plant-based, consisting mainly of cassava, sorghum, millet, soybean, wheat and various legumes and pulses (([63]) Noort et al., 2022), these expected changes will undoubtedly change the consumption patterns of these increasingly urban dwellers from plant-based protein to more animal sources of protein, a phenomenon that has been called the “livestock revolution” ([93]).

* Corresponding author.
E-mail addresses: jeanninemarais@sun.ac.za (J. Marais), sara.erasmus@wur.n (S.W. Erasmus).

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The livestock revolution was originally prominent in the fast-growing developing countries in South America and Asia while SSA took a back role. For example, in the last forty years, China and Brazil accounted for 59% of the increase in global meat consumption. However, the Food and Agriculture Organization of the United Nations (FAO) has projected that meat consumption in South America and Asia is expected to slightly increase and/or stagnate as population growth and GDP reduce ([31]). The exception to these trends is Africa which only contributed about 9% to the increase in global meat consumption in the past four decades. This increasing trend in meat consumption will be more evident in SSA where the population in urban areas will increase as much as fourfold and the GDP will be more than double in the coming decades. Consequently, meat consumption in SSA is expected to increase by 3.4% per year ([31,57]).

The current and forecasted livestock revolution will not be uniform across SSA as some regions will revolutionize faster than others (([67]) Pica-Ciamarra & Otte, 2011). The meat consumption in SSA increased from 13.7 kg/capita/year to 16.2 kg/capita/year from 1973 to 2013 ([57]). While these figures are low compared to the rest of the world, they belie the growth in some SSA countries. For example, from 2003 to 2016, the meat consumption of South Africans increased by 54.4%, from 36.4 kg/capita/year to 66.8 kg/capita/year as disposable income per capita increased at an average annual rate of 3.2%. ([27]). To put this trend into context, around the same period, the average meat consumption in Europe and the United States (U.S.) was about 80 kg and 110 kg/capita/year, respectively ([75]). Furthermore, meat consumption in South Africa (as a SSA country) is expected to increase by an additional 23% between 2016 and 2028 (([14]) BFAP, 2020).

The above-mentioned current and expected increase in meat consumption in SSA will no doubt come with many of the associated human and environmental health risks ([70]), a concern recently termed as “planetary health”. Planetary health involves the task of understanding the dynamic, complex, adaptive, and systemic relationship between environmental health and human health at multiple scales ([69]). Emphasizing the relationships, interconnections, and processes between the environment and humans enable a holistic and systems-based approach to integrated management options for current and future generations ([69]). This is important as there is evidence to suggest that intensive meat production and consumption is detrimental to environmental and human health ([90]). Although there are significant disagreements among experts ([42]), some research has shown that red meat (especially processed meat) consumption has the potential for various cardiovascular diseases, some types of cancer and various instances of meat borne infections ([13,49]) IARC, 2015; [34]). Furthermore, animal production (particularly beef production) is linked to intense deforestation and other environmental degradation ([48,95,105]). Plant-based meat alternatives can meet these concerns.

Plant-based meat also typically called ‘meat analogues’, ‘meat substitutes’, ‘meat alternatives, and ‘imitation meat’ aims to reduce the pressure on meat products demand and offer alternative products to niches such as vegan and vegetarian ([84]). These plant-based meats are “alternative meat” that is made from plant-based ingredients and try to replicate most of the sensory attributes of traditional meat ([16]). Meat alternatives are primarily developed to be used as an alternative to domestic meat species like chicken, pork, and beef and as such sold in recognizable common meat-like processed product forms like burgers, sausages, nuggets, mince, and meatballs ([16]). Currently, the U.S. is the largest consumer of meat analogues in the world, with an estimated value of $1.196 billion in 2018 ([89]). Plant-based meat has also seen remarkable growth in Europe with annual growth of 15-20% in the Netherlands and Sweden, and 5-10% in the United Kingdom (U.K.) in 2016 (([15]) Changing markets foundation, 2018). Worldwide, plant-based meat sales accounted for $12.1 billion in 2019 and it is forecasted to grow by 15% to reach $27.9 billion by 2025 and $149 billion by 2029 ([89]).

Given the current and expected increase in meat consumption in SSA, there is a worrying dearth of research on meat analogues in SSA ([12]), especially given the forecast that the majority of the expected 73% increase in meat demand by 2050 will come from SSA ([31]). Therefore, this review aims to examine the available literature regarding plant-based meat consumption globally and in SSA. For this review, the objectives are to:

i) Examine the promises made by advocates of plant-based meat alternatives regarding their benefits to environmental and human health.
ii) Examine the barriers to meat alternatives consumption, the consumer acceptance of meat alternatives and the strategies to reduce traditional meat consumption.

To the best of our knowledge, this review paper is one of the first of its kind focusing on plant-based meat alternatives in SSA. For a large part of the review, South Africa was selected as a case study for SSA, given that most published work on this topic originated from South Africa.

Material and methods

The literature review followed the guidelines set by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for a structured review ([66]). The review used a mixed-method approach which included quantitative and qualitative research. The Web of Science and Scopus databases were used between April and May of 2021 to obtain journal papers while the Google search engine was used to obtain news or popular articles. The search keywords were TITLE-ABS-KEY (“plant-based meat*” OR “meat alternatives*” OR “meat substitutes*” OR “meat analogues*”). There were no temporal limitations for this review. The results of the literature search are shown in Fig. 1. The initial results obtained were 1819 papers from Web of Science, 2408 from Scopus, and 200 from Google. The titles and abstracts of the articles were screened, and papers related to cultured, cell-based, in-vitro, lab-grown, clean, cultivated, insect-based, microbial, and other alternative protein sources were removed. Thereafter, the full texts of the remaining literature sources were examined. Papers and

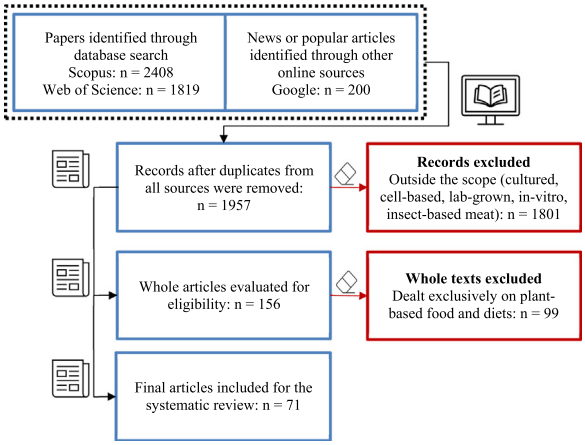

Fig. 1. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow of the systematic review process with reasons for exclusion.

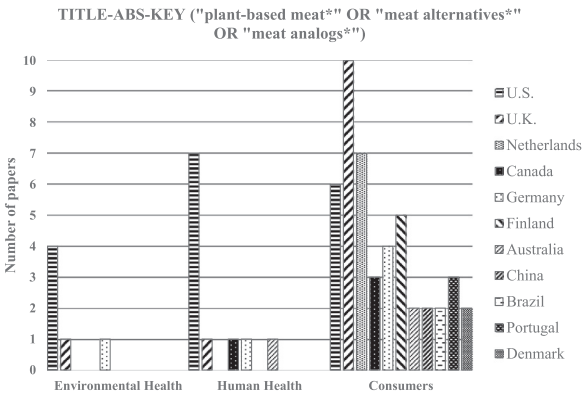

Fig. 2. Distribution of papers on plant-based meat alternatives.

news articles that focused on plant-based food and a plant-based diet were removed except if they dealt with barriers to and consumer acceptance of these types of food. The remaining articles were downloaded and exported to the Mendeley desktop application where duplicates were removed. The final set contained 71 relevant papers (18 from Web of Science, 39 from Scopus and 14 articles from Google) (Fig. 1).

Results

The details of the literature sources selected for the review are shown in Table A.1 (provided as Supplementary material, Appendix A). Research on the modern versions of plant-based meat analogues is relatively new as the articles were published between 2011-2021, with 2015 being the year with the most published articles. The distribution of papers on plant-based meat alternatives is shown in (Fig. 2). Most of the studies were conducted in the U.S. and the U.K. while the rest were conducted in countries in the European countries (i.e., Netherlands, Belgium, Portugal, Germany, Finland, and Denmark) and Canada. One study was performed in Australia and transnational studies were done in the U.K., Spain, Brazil, the Dominican Republic, U.S., India, and China.

An overwhelming majority of the studies were quantitative while the others were reviews and theoretical/conceptual papers with just two qualitative studies. The studies were published in various journals, with many of them published in Food Quality and Preference, Appetite, British Food Journal, Sustainability, and Frontiers in Sustainable Food Systems.

Discussion

The evolution of plant-based meat alternatives

Tofu, a soy product that has been produced in China for about 2000 years, is the earliest known food that can be classified as a meat substitute. Vegetarians in the U.S. and Europe have been familiar with tofu since the 1960s (([85]) Shurtleff & Aoyagi, 2014). However, other meat analogues were introduced to the vegetarian market around the same time. Other

Table 1
The nutritional composition (per 100 g) of different plant-based meat alternatives compared to a traditional McDonalds™ beef patty.

Product (100 g) Nutrients	McDonalds™ beef patty	Impossible™ patty	Beyond™ patty	Big Fry™ patty	Gudness™ sandwich slice
Carbohydrates (g)	*	8.0	2.7	8.0	3.0
Protein (g)	23.3	16.8	17.7	17.7	7.5
Total fat (g)	20.0	12.4	15.9	4.0	10.2
Saturated fat (g)	8.3	7.1	5.3	0.6	6.3
Dietary fiber (g)	0	2.7	1.8	3.1	1.8
Energy (kcal)	266.7	212.4	221.2	144.0	134.1
Cholesterol (mg)	83.3	*	*	*	*
Sodium (mg)	400.0	327.4	345.1	709.0	1306.0

Sources: ([106]) Bohrer (2019); Gudness™ website: www.gudness.co.za; Big Fry™ Burger website: www.fryfamilyfood.com/za (see ingredients and nutritional information). *None reported.

examples of food that can be classified as meat alternatives over the years include Seitan, Quorn and Tempeh. It was not until the 1990s that food technology began to develop and introduced a product called “textured vegetable protein” (TVP) (([85]) Shurtleff & Aoyagi, 2014). However, many of the technologies used in meat analogues today, including biopolymer spinning and extrusion, were first patented in 1947 and 1954, respectively (([85]) Shurtleff & Aoyagi, 2014). With this technology, soy protein was spun into fibres with low moisture cooking extrusion to form fibrous products that mimicked meat ([7];). Even though these early meat analogues were not readily accepted by consumers ([74]), they were further developed due to advancements in extrusion cooking technologies. With the introduction of high moisture extrusion cooking and the incorporation of ingredients from other food sectors such as the use of hydrocolloids, (([97]) Tsiva et al., 2020) extrusion cooking allowed for the development of better products in terms of texture and taste (([97]) Tsiva et al., 2020).

Companies like Impossible Foods and Beyond Meat™ make meat analogues that have dominated the news in the U.S. since 2017. They promote a meat-like product that mimics traditional meat in palatability ([51]). Impossible Meat™ contains soy leghemoglobin which contributes to a meat-like mouthfeel and taste while Beyond Meat™ burger uses beet juice extracts that make its products look and “bleed” like traditional meat ([51]). Plant-based meat alternatives in SSA are not as ubiquitous or well known as their western counterparts. However, in South Africa, there are some plant-based meat alternatives such as the Big Fry™ products from Fry Family Food Co. (www.fryfamilyfood.com/za), and Gudness™ products, from Feinschmecker Deli Meats (www.gudness.co.za).

As such, meat analogues are classified into first- and second-generation meat analogues (([97]) Tsiva et al., 2020; [42]). This paper focuses mainly on the second-generation meat analogues of Impossible Meat™, Beyond Meat™, and the locally made meat analogues partly because it is expressly marketed to meat-eaters and non-meat eaters alike ([50;54]) and is currently widely available in some SSA countries.

Ingredients and the nutritional composition of plant-based meat

The protein ingredient used in the production of plant-based meat is without doubt the most important component (([106]) Bohrer, 2019). Protein provides structure and promotes interactions that affect flavor-binding, viscosity, gelation, and texturization ([24]). Soy protein has historically been the most widely used protein source for plant-based meat products (([106]) Bohrer, 2019). Generally, processed soy protein concentrates have been shown to have a greater proportion of indispensable amino acids. This has given processed soy protein a protein digestibility-corrected amino acid score (PDCAAS) ranging from 0.92 to 1.00, depending on the PDCAAS analytical method (([107]) Hughes et al., 2011), comparable to animal-derived sources of protein. However, problems associated with soy proteins such as the presence of allergens, a beany taste, and the lower values of some indispensable amino acids like lysine and methionine has led to researchers advising the use of a combination of protein sources (cereal protein and legume protein) in meat analogues for nutritional and functional purposes ([50,106]) Bohrer, 2019). From a functional point, some cereal proteins such as wheat gluten are viscoelastic which assists with the binding of the product and provide homogeneity in meat analogues ([60]). Legume (lentil, pea, lupine fava bean) protein are increasingly popular as they are greatly complementary and offer more unique properties (([106]) Bohrer, 2019).

Even though original meat analogues were low in lipids ([54]), recent meat analogues contain a significant amount of lipids to mimic that of traditional meat products (([106]) Bohrer, 2019). The nutritional composition of popular plant-based meat alternatives is shown in Table 1, and evidently, the Beyond™ patty has a total fat content similar McDonalds™ beef patty. The lipid source of meat analogues, is also diverse, ranging from unsaturated canola oil and sunflower oil to more saturated coconut oil (([106]) Bohrer, 2019). The functional utility of lipids is for tenderness, juiciness, mouthfeel, and flavor ([55]).

Carbohydrates used in meat analogues can be categorized as starches or flours used for texture, consistency, and binding ingredients or gums like xanthan gum and acacia gum used for product stability and form (([94]) Tarté, 2009). The functional purpose of carbohydrates is to improve interactions between the protein, lipids, and water components to form a stable structure (([94]) Tarté, 2009). In addition, other ingredients like spices and seasoning (([106]) Bohrer, 2019) and the isolates of specific naturally occurring volatile compounds are used as flavor enhancers ([55]) while beetroot and tomato

Table 2
The life cycle assessment of a beef patty vs. a Beyond Meat™ burger patty [43].

Impact category	Unit	Beef patty	Beyond Meat™ burger patty
Greenhouse gas emissions	Kg CO_2 eq.	3.7	0.4
Energy use	MJ	11.4	6.1
Land use	M^2a eq.	3.8	0.3
Water use	Litre eq.	218.4	1.1

Table 3
The life cycle assessment of a beef patty and an Impossible Meat™ burger patty [52].

Impact Category	Unit	Beef patty	Impossible Meat™ burger patty
Aquatic eutrophication potential	G PO_4 eq.	15.1	1.3
Global warming potential	Kg CO_2 eq.	30.6	3.5
Land occupation	M^2.y	62.0	2.5
Water consumption	Litre eq.	850.1	106.8

juice are most often used as coloring agents ([106]) Bohrer, 2019). Nutritionally, research has shown that plant-based meat alternatives should not be viewed as interchangeable with traditional meat as there can be as much as 90% differences in nutrients (various vitamins, amino acids, minerals, dipeptides, antioxidants, saturated and unsaturated fatty acids). For example, minerals such as iron is reduced in meat alternatives, while the iron present in traditional meat (in heme form) is more bioavailable than non-heme form present in legumes used in meat alternatives. Another example is zinc, which is also reduced in meat alternatives due to the lectins, phytates and other anti-nutrients ([40]). Even though further nutritional enhancement of meat alternatives may improve the similarity with traditional meat, research has shown that a flexitarian approach (reducing traditional meat and supplementing with meat alternatives) is safer and unlikely to be deleterious to nutritional status of consumers ([101]).

The ingredients in South Africa's plant-based meat are similar to that of western alternatives with an example like the Big Fry™ burger patties containing soy, wheat, rice, quinoa, and chia seeds as protein sources, sunflower, flaxseed, coconut, and palm oils as lipid sources, potato and maize starches as carbohydrate sources, methylcellulose as a thickener, and herbs, vegetables, tomato, onion, mustard, coloring and flavoring enhancers (www.fryfamilyfood.com/za). Gudness™ deli slices contain amongst other things, isolated soy and pea proteins, carrageenan, konjac gum, guar gum, locust bean gum, modified starch, various spice extracts, beetroot, and currant as coloring agents, as well as flavor enhancers (www.gudness.co.za). Generally, both South African alternatives have a similar nutritional composition when compared to other plant-based meat alternatives as shown in Table 1. Finally, in terms of nutritional composition (macronutrients and other minerals) between traditional meat and meat alternatives, there is inconclusive evidence on which is healthier. Research has shown that healthiness is a measure of the ingredients used to make the products. However, it is obvious that there is no "one size fits all" approach when comparing the nutritional composition of meat alternatives with traditional meat and the onus is on the consumer to investigate in order to make informed choices ([106]) Bohrer, 2019)

The environmental footprint of plant-based meat

Life cycle assessment (LCA) is a method used to determine the environmental impact of a specific product ([108]) Smetana et al., 2015). Although there is no standardized method of performing LCA, various researchers have tried to compare the environmental impacts of meat alternatives with traditional meat. [43] conducted a LCA on the Beyond Meat™ Burger patty to compare the environmental impacts (greenhouse gas emissions, energy use, water use and land use, amongst other things) with a traditional burger patty from conventional beef production. While [52] did a LCA on the Impossible Meat™ burger and a traditional beef burger. As shown in Tables 2 and 3, plant-based meat alternatives outperformed traditional meat in all the selected environmental measurement. While these studies show significant differences in the environmental footprint between traditional burgers and plant-based burgers in Western nations, LCA studies on meat alternatives produced in SSA are still absent.

On the other hand, ([32]) Fresan et al. (2019a) did an LCA for the water footprint of meat analogues. They found, that producing one metric ton of meat analogues consumed 3800 m^3 of water, could release 0.56 kg phosphorus equivalents and 2.2 kg nitrogen equivalents into fresh and marine waters, respectively. Also, one metric ton of meat analogues could release 12 kg and 7 kg of 1,4-dichlorobenzene equivalents into fresh and marine waters, respectively. Consequently, the processing of meat analogues is the main driver for water consumption and marine ecotoxicity while the production of meat analogue ingredients is the main driver for freshwater ecotoxicity. In addition, the impacts of packaging and transportation of meat analogues had the least impact on water consumption, freshwater, and marine ecotoxicity. It was concluded that while meat analogues represented a more sustainable option in terms of water footprint, the water footprint of meat analogues was only higher than processed traditional meat products. However, because of the processed nature of meat analogues, it had a similar water footprint to unprocessed or minimally processed traditional meat products. Furthermore, ([33]) Fresan et al. (2019b) found that GHG emissions were similar for meat analogues regardless of the protein source (soy, wheat, nuts).

However, the presence of eggs in a meat analogue significantly increased its GHG emission. The results remained the same when examined through different functional units (100 g of meat analogue, 20 g of protein, and 100 kcal). Finally, the intensive monocultures used to produce most crop plants used for plant-based meat could shift the environmental burden and should be considered in any holistic assessment of the environmental footprint of plant-based meat.

Health impacts of plant-based meat alternatives

Research into the health concerns of meat alternatives have focused more on the health risks of traditional meat as opposed to the health concerns of meat alternatives. This is probably because researchers have equated meat alternatives to other plant-based food and have associated the health benefits of a plant-based diet to plant-based meat, but nutritional experts have cautioned against this and calls have been made for long term studies on the overall health impacts of plant-based meat ([47]). Furthermore, the health impacts of some of the ingredients in plant-based meat-like methylcellulose ([82]) and various gums (([10]) Biswas et al., 2011) warrants attention as there is possible gastrointestinal health concerns with these ingredients (([106]) Bohrer, 2019). In addition, the health risks linked to soy leghemoglobin in some plant-based meat ([8]) and the high levels of sodium in South African versions of meat analogues ([61]) is a cause for concern. Regardless, plant-based meat alternatives have some important health benefits. It contains no cholesterol, while the higher fibre content relative to traditional meat is known to reduce risks of cardiovascular diseases, diabetes, and colorectal cancer ([34]). However, it is still low in proteins and high in carbohydrates and salts. Consequently, the "halo effect" (the perception by consumers of plant products being more environmentally friendly) ([91]) surrounding meat analogues may not be entirely warranted and requires further validation.

Barriers to mainstreaming plant-based meat

Meat places a central role in our diet as it is usually depicted in the centre of meals ([46]) and fulfils many more purposes. Over time, meat consumption becomes a normal part of life. Furthermore, it is believed that meat in our food is nutritionally irreplaceable ([58]). This is the first thing that proponents of plant-based meat need to understand, that a reductionist approach (reducing meat to mainly its nutrient components) might not be effective with meat. Meat is eaten for many more reasons than just physiological needs. [68] found that meat enjoyment is the most significant barrier to eating plant-based meat or a plant-based diet. In addition, meat has important socio-cultural connotations, which includes status, power, hierarchy, and subjugation of others ([39]). Other important attributes associated with meat are a nutritional necessity, eating routines and habits, convenience, and versatility ([46,58,71]).

Even though the local diets of SSA have traditionally been meals made from crops like sorghum, cassava, millet, and pulses, as stated earlier, increasing disposable income is necessitating a change in diet to more animal sources of protein (([63]) Noort et al., 2022). However, the socio-cultural connotations with meat-eating are likely to be more pronounced in SSA as meat-eating has a deeper meaning. For example, ([6]) Asamane et al. (2021) found that in Zambia, meat-eating, and sharing connotes economic prosperity in households in addition to power and respect. Furthermore, they found that even the type of meat served has various connotations. Chicken was more popular for regular consumption in households and entertaining guests as it is more readily accessible and relatively cheaper. On the other hand, beef is reserved for important visitors and landmark celebrations as it usually implies wealth because it is more expensive and usually eaten by well-to-do households. ([30]) Erasmus and Hoffman (2017) found that meat is an important part of the South African cuisine as different types of game meat plus domesticated animals have been consumed for centuries, even before colonial times ([87]). In addition, they found that different ethnic groups in South Africa have various cuisines made from different types of domesticated and especially game animals (meat derived from free-roaming wild animals). Consequently, there is a possibility that meat analogues will be viewed as inferior to those consumers with very strong socio-cultural attachment to meat-eating.

Regarding meat consumption, men, older people, low level of education, and even absence of pets are related to higher meat consumption patterns ([35,38,72,78,83]). The interesting thing about meat consumption is that even though consumers acknowledge the environmental and health risks associated with regular meat-eating, they are still unlikely to change or even reduce their meat consumption for the sake of their health or the environment, a phenomenon known as the "meat paradox" ([102]). In other words, their purchasing behavior is not in line with their concerns ([102]). Cognitive dissonance (mental conflict where a person's beliefs and behaviors do not align) is known to partly account for this paradox as denying animals physiological characteristics, having the perception that animals suffer less and moral justification of meat-eating are just some of the ways consumers account for the incongruence of their behavior ([11]). Otherwise, acknowledging these factors invokes a feeling of disgust at eating animals (([80]) Ruby & Heine, 2011). Feelings of disgust is an important factor in determining the willingness to eat a particular food ([79]). Furthermore, there is a clear distinction between meat production and meat consumption. Marketing and packaging in stores paints pictures of happy and smiling animals, reduced or absent visual cues of blood, the living conditions of animals and the slaughtering process, reduced "animal-ness" (the degree to which they remind consumers that the source was once a living animal) through smaller cuts rather than whole parts ([1,41,79]). Consequently, consumers have little to no experience of meat production systems and hence a reduced feeling of disgust at eating animals ([22]). As [90] succinctly put it, "most people would not be able to eat the meat on their plate if they were obliged to slaughter, skin and gut it". However, even though consumers may theoretically express worry about

the health, environmental, and animal welfare issues around meat production and consumption, in practice, other concerns such as price usually take precedence ([103]). Price is another significant barrier to the adoption of plant-based meat. ([110]) Ritchie & Roser, 2017 explained that unless the relative prices of meat alternatives decline significantly, it is unlikely to gain a substantial share of the meat market even though social acceptability is high. Furthermore, [86] found that an increase in the price of meat analogues by $1 increases the market share of traditional meat by 6%; showing that price is an important factor that consumers consider. In South Africa, recent research has shown that price is a significant barrier to purchasing plant-based meat alternatives as these products were a niche product that aligned with status and class ([98])

Even though disposable income is increasing in low and middle-class consumers in SSA ([96]), it seems unlikely that these sections of consumers will completely or even partially forgo traditional meat products for meat analogues. If anything, the reverse is more likely as evidenced in the "livestock revolution" ([93]). Consequently, while this aforementioned section of consumers can substitute traditional meat with meat analogues, it will be a difficult challenge as these consumers are just coming into an income stream needed to indulge their meat pleasures. This difficulty is exacerbated especially when coupled with the socio-cultural connotations of meat-eating.

Consumer acceptance of plant-based meat

Aversion to unfamiliar foods (food neophobia) ([44]) and variety seeking ([100]) are key factors for consumer acceptance of meat analogues. If meat analogues are considered novel, consumers expect them to taste unpleasant and may be unwilling to try them (([109]) Pliner et al., 1993). Research in South Africa has shown that familiarity is the strongest indicator towards the consumption of plant-based meat alternatives ([93]). Regardless, food neophobia might be reduced if the plant-based meat has the same sensory, visual, and labelling properties as the traditional meat products they are familiar with ([44]). [1] found that although consumers (University students) expected plant-based meat alternatives to taste unpleasant, those that tried and liked it, liked it even more when they were told it was not traditional meat but plant-based meat. The authors attributed the latter to the "halo effect" of plant-based meat as consumers perceived this food as being better for their health and the environment (([71]) Povey et al., 2001).

Product newness is another factor that affects consumer acceptance of meat analogues over time ([99]). Research shows that new foods may be initially rejected, although repeated exposure may increase its acceptance ([45]) this may be tempered by how novel the food looks (([53]) Koster & Mojet, 2007)

Meal context is another important aspect that plays a huge part in consumer acceptance of meat analogues. Studies show that meals, where meat analogues replace smaller or less pronounced pieces of meat, are more successful ([2]). As [29] hypothesized and confirmed, the choice of meat alternatives in meals plays a huge role in taste, texture, and the eventual acceptance of meat analogues. For example, meat alternatives will be perceived differently in products like soups or pasta dishes. Furthermore, [44] found that consumers' perception of meat was largely influenced by the source and as such, they grouped traditional meat products separately from meat analogues. However, this changed for processed products as consumers, for example, grouped traditional hamburgers in the same category as vegetarian burgers based on appearance, showing that the product form and not the product source dominated.

As earlier stated, sensory qualities of meat analogues are important characteristics for the acceptance of meat analogues ([12]). Research has shown that consumers who eat meat finds it necessary for meat alternatives to look like traditional meat, while vegans and vegetarians do not have this preference ([4,21]) Cordelle et al., 2022). Consequently, there have been numerous studies done trying to further improve the appearance, texture, and taste of meat analogues and many of these studies have produced significant improvement in the sensory qualities of meat analogues ([9]).

The welcome afforded to plant-based meat analogues has been worthwhile, with a large majority of restaurants in SSA countries like South Africa peopled by meat-eaters and non-meat eaters alike requesting plant-based meat, with some restaurants divulging that as much as 50-60% of plant-based meat-eaters are regular meat-eaters (([65]) News24, 2019). A large part of this welcome afforded to meat analogues has been due to organizations like ProVeg (www.proveg.com/za) and Infinite Foods (www.infinitefoods.com), organizations aiming to transform the global food system from traditional meat products to more plant-based products. Infinite foods have especially been instrumental in bringing meat alternatives to SSA with retail outlets in South Africa, Botswana, Mauritius, and Kenya with plans to open retail outlets in other SSA countries in the future ([20]).

Strategies to reduce meat consumption

[37] divided consumers into three categories regarding meat-eating (no-meat, meat avoidance, and meat attachment), while [76] identified nine strategies meat-eaters use to justify their meat-eating which was classified into apologetic and unapologetic strategies. Consequently, both researchers identified different strategies to reduce meat consumption according to their reasons for meat-eating.

The literature is replete with strategies to reduce traditional meat consumption and to try plant-based meat alternatives instead. They include, but are not limited to, a meatless day or "meatless Mondays", partially substituting traditional meat with plant-based ingredients (e.g., "hybrid burgers"), cultural and lifestyle changes, food labelling, consumer education, taxes on traditional meat or subsidies on plant-based meat ([25,45,92,26,56,88,5,62,73]). However, some of these strategies are not without drawbacks. For instance, food labelling on the health and environmental benefits of plant-based meat may suffer

from a deluge of information, most times it is found to be confusing and competing ([3,104]). [19] found that food labels, family/friends, and the internet are the most common source of information on protein alternatives. However, only about half of the consumers trust the information from food labels and family/friends, while over 80% do not trust the information received from the internet. On the other hand, 13% and 18% of consumers obtain their information from health experts and the government, respectively, but the trust in these sources is about 87% and 66%, correspondingly. The [19] study provides a useful insight into the consumer experience and shows the sources that they trust for information are not readily available while the readily available sources of information are not particularly trusted. This study presents an opportunity for health experts and the government to increase their outreach to consumers. Another example of consumer education might not affect ([28]) and/or have the opposite effect as people are deeply rooted in their behaviors (([36]) Graca et al., 2014). Taxes and subsidies may entail significant pushback from the traditional meat industry, relevant stakeholders, and even consumers ([64]). A more holistic approach that combines some or all the above strategies has been championed ([23]). As [90] aptly put it, "changing consumer behavior is hard enough, even in the face of well-established, evidence-based public health policies (e.g., smoking)".

Research has shown that human health, environmental health, and animal welfare are some of the major reasons for a vegetarian and vegan diet ([81]). Advocates of plant-based meat do not need to convince this section of consumers of the benefits of meat analogues, the same goes for reduced meat-eaters or "flexitarians". As [5] found, the values of meat analogues that resonates with this section of consumers should be placed front and centre. Different strategies should be employed as appeals to human health, environmental health or animal welfare may fail with strong meat-eaters ([77]). Here, strategies like reduced meat sizes, an expanded concept of what counts as meat, meatless days and even hybrid meat should be used instead ([26,56,37,62,73]). It should be strongly noted that it does not have to be an "either/or" or "the same but better" scenario between traditional meat and meat analogues but a complementary relationship. Plant-based meat should be marketed as a complement to traditional meat, not as an outright replacement [17],[59]. Indeed, diets entirely bereft of meat is usually considered by consumers as "over the top" or excessive ([18]). This is probably because meat-eating consumers view vegan diets as too far from their own and are more likely to use cognitive dissonance strategies to justify their continued meat-eating ([77],[12]). [12] discussed that proponents of meat analogues should consider advocating vegetarianism rather than veganism as vegetarianism is an achievable target.

Even though a majority of consumers still are not aware of the environmental burden of animal production (([41]) Hartmann & Siegrist, 2020), [12] found that consumers do not need to hear more of this but as earlier stated, taste, price, and convenience are some of the barriers to meat analogues. As [12] discussed, these barriers are more practical than ideological and consequently need practical solutions like improved visual and sensory qualities of meat analogues and competitive prices concerning traditional meat products ([44,81]). While the environmental and health impacts of meat production and consumption in SSA countries are similar to those of the West, whether consumers are aware of this remains to be seen as research is practically non-existent.

Knowledge gaps and future research

Even though different versions of meat analogues have been available in South Africa and the rest of SSA over the past 25 years, comprehensive research on the health and environmental impacts of these products is lacking. However, with the introduction of Impossible Meat™ and Beyond Meat™ in addition to locally made meat analogues into the market; knowledge, and consumption of these products are bound to increase. Consequently, there is a need for a comprehensive environmental assessment of locally made meat analogues in SSA, the local crops used for their production and its environmental implications. Furthermore, long term health impact assessments of local meat analogues are also needed. Finally, the social dimensions such as the social implications of reducing meat consumption, barriers to meat analogues, consumer acceptance of meat analogues, and strategies to reduce meat consumption in SAA is practically non-existent and is sorely needed for a large-scale adoption of meat analogues in these countries.

Conclusions

Different versions of meat analogues have been available over the past 2000 years with varying levels of success. However, it was not until recently that newer versions of plant-based meat analogues have improved enough to the extent that it has been marketed to meat and non-meat eaters alike. Consequently, it has been heralded as an alternative solution to the adverse human and environmental health risks of traditional meat production and consumption. This review has shown that the "halo effects" afforded to meat analogues are not completely warranted due to researchers are (un)knowingly discounting the processed nature of meat analogues in any environmental or health risk assessment. While the reduced environmental impacts of meat alternatives are apparent, a 'cradle to grave' environmental assessment needs to be carried out to ensure that the environmental burden is not shifted to other stages in its lifecycle. Even though the nutritional composition of some meat alternatives is comparable to the traditional meat counterparts, the health concerns of ingredients used to produce meat analogues require more long-term research. Furthermore, this review has shown that meat is eaten for more reasons other than physiological needs and hence getting consumers to reduce their meat consumption and/or substitute meat for meat analogues involves knowing these reasons and tailoring marketing strategies to different sections of consumers. This contextual approach is bound to provide more favorable and long-term results than a "one size fit all"

strategy. Regardless of the marketing strategy employed, it is proposed that meat analogues should not be marketed as a replacement for traditional meat products but as a complement. Lastly, even though meat analogues have been available in SSA, specifically South Africa, for quite some time, it is now gaining more traction due to various reasons such as the increase in vegetarians and vegans. However, price and the socio-cultural connotations associated with meat-eating are among the biggest barriers to mainstreaming meat analogues in SSA. Even though the limited research published in SSA seem to confirm the studies published in the global north still holds in SSA, there is still a need for more local research. These research on SSA are bound to provide more nuanced and contextual factors on consumer acceptance, strategies to reduce consumption amongst other things are sorely needed if plant-based meat alternatives have any chance of complementing the SSA diet.

Author contributions

All authors acknowledge that they have contributed to and approved the final version of this article. **Omamuyovwi Gbejewoh**: Conceptualization; Methodology; Formal analysis; Resources; Investigation; Writing - original draft, review & editing. **Jeannine Marais**: Writing - review & editing; Supervision. **Sara W. Erasmus**: Conceptualization; Resources; Writing - review & editing; Supervision.

Declaration of Competing Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Supplementary materials

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