



Perspectives of Meat Eaters on the Consumption of Cultured Beef (*in vitro* Production) From the Eastern Cape of South Africa

Bamidele Andrew Falowo¹, Yiseyon Sunday Hosu^{2,3} and Emrobowansan Monday Idamokoro^{2,3*}

¹ Department of Animal Science, Adekunle Ajasin University, Akungba-Akoko, Nigeria, ² Small-Scale Agribusiness and Rural Non-farm Enterprise, Niche Area, Walter Sisulu University, Mthatha, South Africa, ³ Faculty of Commerce and Administration, Department of Economics and Business Sciences, Walter Sisulu University, Mthatha, South Africa

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*Correspondence:

Emrobowansan Monday Idamokoro
midamokoro@wsu.ac.za;
mondridaydamokoro@gmail.com

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The creation and growing popularity of cultured meat has raised mixed reactions among consumers about its originality, acceptability, edibility, and nutritional quality across the world. The perception and reaction of consumers to novel meat are influenced by a variety of factors, such as geographical location, media coverage, educational status, culture, and religion. Therefore, this study was designed to examine the perceptions of consumers on the consumption of natural vs. cultured beef in the Eastern Cape Province, South Africa. A total of 255 respondents were interviewed using structured questionnaires, and the data were analyzed using descriptive statistics and X^2 tests. Interviewees included representatives from University (educated), urban (literate), and rural (semi-literate) communities. The results revealed the majority (63%) of the respondents had not heard about the concept of cultured beef production, of which 27% of them were men and 36% were women. More than half (53%) of the respondents indicated their willingness to eat cultured beef if offered to them after explaining the concept and process of making cultured beef to them. Among all factors that were analyzed, the participant level of education was found to significantly influence their willingness to eat cultured beef when available commercially. It is therefore concluded that the majority of consumers in this study supported the concept of cultured meat as an alternative way to complement conventional meat production and would be willing to eat it when provided.

Keywords: meat eaters, perceptions, cultured beef, meat production, meat

INTRODUCTION

The geometric rise in meat consumption across the world over the past few years has been phenomenal. Presently, worldwide average meat consumption is estimated at 42.9 kg per capita, with industrial countries consuming about 76.1 kg, two times the quantity in developing countries (33.6 kg) (FAO, 2014; WWF Report, 2016). However, it has been indicated that the consumption of meat and meat products will double by 2050, and beef consumption will increase by 200% in developing countries (FAO, 2011; Chriki and Hocquette, 2020). This increase could be attributed to several reasons, including (a) the processing of meat into ready-to-eat products (such as, sausage,

polonies, and patties), (b) the application of innovative technologies to increase production and improve qualities, such as tenderness, leanness (fat content), palatability, freshness, shelf life, and safety, (c) awareness on its inherent essential micronutrients, such as iron, zinc, calcium, vitamin A, vitamin B1, and other bioactive compounds (Datar and Betti, 2010). Beyond this, the shift toward high meat consumption has been attributed to an increase in income and the human population, which has been forecast to reach 9 billion in 2050 (Nellemann et al., 2009; Alexandratos and Bruinsma, 2012; OECD-FAO, 2021). As the world becomes more developed and prosperous, the global consumption of meat (such as, beef) will continue to rise enormously in the coming decades (van der Weele and Tramper, 2014; OECD-FAO, 2021).

As a consequence, satisfying the demand for meat without an alternative means of meat production will be a great challenge (Post, 2012; Goodwin and Shoulders, 2013). Innovation and productivity improvements alone in conventional beef production may not be enough to mitigate these challenges. Any further attempt to engender intensive (mass-scale) meat production may cause more harmful effects on the environment, public health, and the global economy (Smil, 2014). Similarly, commitment to vegetarianism or a meatless diet (meatless Monday) will not fundamentally affect future demand for meat (Smil, 2014). Therefore, the production of alternative meat sources, such as cultured meat among others is seen as a hopeful option to complement conventional beef production (Tuomisto, 2010; Zaraska, 2013; Chriki and Hocquette, 2020). *In vitro* meat, also known as “cultured or clean meat” is meat produced without slaughtering the animal from embryonic stem cells or adult stem cells (Post, 2012; Post et al., 2020; Newton and Blaustein-Rejto, 2021). Given the appropriate technology has been fully developed, cultured meat could be seen as an option to diminish the increasing problems associated with meat production, such as greenhouse emissions, animal welfare (suffering caused by intensive farming), the mass slaughter of animals, and health claims (Chiles, 2013; Hocquette et al., 2015; Newton and Blaustein-Rejto, 2021).

Moreover, the creation of cultured meat has raised mixed reactions among consumers about its originality, edibility, and nutritional quality. However, it is worth noting that the world's first cultured beef burger was launched on 5 August 2013 for sensory evaluation in London (Riverside TV studios) in front of a live audience and was streamed internationally for an interested individual to gain familiarity with the technology (Zaraska, 2013; O’Riordan et al., 2017). Yet some consumers are skeptical about the suitability of the meat. Verbeke et al. (2015) in a survey study conducted in Belgium, Portugal, and the United Kingdom revealed that most participants were disgusted when they first heard about the cultured meat, while others thought it was ridiculous and completely unnatural. In the United States, Wilks and Phillips (2017) revealed in an online survey study that one-third of the respondents showed a willingness to eat cultured meat regularly or as a replacement for farmed meat when provided. In another study involving an analysis of 34 United States and European Union newspapers, Goodwin and Shoulders (2013) found a statement indicating that if cultured

meat feels and tastes similar to meat, people will buy it. Laestadius and Caldwell (2015) observed the comment of consumers in an online newspaper survey and found that the majority described cultured meat as an unnatural and unappealing food. However, in Africa, limited or no information is available on the knowledge and reaction of consumers to cultured meat.

Presently, cultured meat is yet to be commercially available. However, some researchers are convinced and optimistic that its production will reduce the meat industry's environmental footprint, while others have criticized its potential or advantages (Hocquette et al., 2015; Newton and Blaustein-Rejto, 2021). It is expected that factors, such as media information, culture, religious belief, public involvement, affluence, age, level of education, health-related issues, and trust in science and technology could influence the perception and reaction of consumers to food products (Chiles, 2013; Fayemi and Muchenje, 2014; Font-i-Furnols and Guerrero, 2014; Verbeke et al., 2015). To some extent, craving for originality, nutritional quality, and healthiness can also determine consumer perceptions and acceptance of cultured meat (Guerrero et al., 2013).

Therefore, the objective of this study was to investigate the perceptions of meat consumers regarding the potential and willingness to eat cultured beef (*in vitro* meat production) in the Eastern Cape Province, South Africa.

MATERIALS AND METHODS

Study Site and Sampling

The study was conducted in the Eastern Cape Province of South Africa. The Eastern Cape is the second largest province in the country covering approximately 169,580 km² (13.9%) of the total land area of South Africa. The province is located on the east coast of South Africa with an average population of 6.62 million people constituting about 12.5% of the country's population. The province is largely dominated by blacks, of whom 78% are Xhosa-speaking. The Eastern Cape is regarded as the home of livestock, having the highest number of beef cattle production in the country (DAFF, 2013). The chosen municipalities in the province for this study include Nkonkobe (Alice and Dimbaza), Buffalo city (Mdantsane and KingWilliams town), and Alfred-Nzo (Mount Frere and Mount Ayliff). According to their geographical location, the three municipalities were further stratified into three groups to include University (Alice), urban (Mdantsane and KingWilliams town), and rural (Dimbaza, Mount Frere, and Mount Ayliff) communities. The stratification of the municipalities in this study supports the widely-held view that consumer perception varies according to geographical location (Dindyal and Dindyal, 2003). The total population of the people living in the study area selected for this study is < 2 million. With the use of the Raosoft calculator, and the confidence level set at 95% (with the confidence interval at 5%), the total expected sample size is 384 participants.

Data Collection

The data used in the present study were obtained from 255 respondents. This was so because of some constraints, such as scarce resources, the inability of respondents to properly

answer the questionnaires, and the lack of willingness of some respondents to partake in the study. Of the 255 respondents, 101 participants were selected from the university community, 66 from the urban community, and 88 from the rural community. Meanwhile, the larger the population of a given area does not necessarily increase the sample size of the area (Krejcie and Morgan, 1970). A snowball sampling technique was used to collect the data. We aimed to get representation from a wide variety of perspectives, and interviewees were selected from universities (those that have unlimited access to information, especially through social media, such as the internet), urban (those that are literate) and rural (those that are semi-literate) communities. Questionnaires (with closed-ended questions) were administered through personal contact in the respondent's residence. Those respondents that do not fill their questionnaire properly and completely from all the categories were also excluded from the analysis. The respondents provided information on demographic characteristics (such as, age group, gender, and education), perception on the consumption of beef, possible reasons of not eating beef, and knowledge and willingness to eat cultured meat (*in vitro* production), if provided. Some of the questions asked about the consumption of beef include (i) do you eat meat from cattle, (ii) how often do you eat meat from cattle, (iii) what are the factors influencing the choice/purchase of beef, and (iv) possible reasons why you do not eat beef. While questions asked on knowledge and willingness to eat cultured meat include (i) have you heard about or aware of the production of *in vitro* meat, (ii) do you agree that the production of *in vitro* meat/beef is important for enhancing food security, (iii) will you like to eat *in vitro* meat/beef if provided, and if no, give a reason. Before data collection, a group of experienced field workers that could effectively communicate with the respondents in vernacular (Xhosa) and English Language were recruited to administer the questionnaires. Each member of the group was trained on how to administer the questionnaire correctly and also describe the cultured meat for easy understanding of the respondent. The primary term used to describe the "cultured meat" includes meat grown in the laboratory from the adult cells of an animal.

Statistical Analysis

Data were analyzed using the Frequency procedure (PROC FREQ) and the chi-square procedures (PROC CHISQ) of the Statistical Analysis System (SAS, version 1.9.3 of 2007). PROC FREQ was computed based on the age groups, gender classes, tribes, locations, and levels of education of the respondents. PROC CHISQ was used to determine the association between demographic characteristics of the respondents and their perceptions of the production and consumption of *in vitro* cultured beef.

RESULTS AND DISCUSSION

Consumer Distribution and Socio-Demographic Characteristics

Results on participant's distribution according to locations showed that the university community had the highest

TABLE 1 | Demographic characteristics of the respondents ($n = 255$).

Variable	Group	Value	Proportion (%)
Gender	Male	121	47.5
	Female	134	52.5
Age	<18	9	3.5
	18–30	123	48.2
	31–40	42	16.5
	>40	81	31.8
Education	Primary	14	5.5
	Secondary	71	27.8
	Tertiary	148	58.1
	Others	22	8.6
Tribe	Xhosa	217	85.1
	Non-Xhosa	38	14.9
Location	University	101	39.6
	Urban	66	25.9
	Rural	88	34.5

proportion of respondents (39.6%), followed by urban (34.5%) and rural (25.9%) dwellers, respectively (Table 1). Regarding the socio-demographic characteristics of the respondents, 47.5% were men and 52.5% were women. Nearly 50% of the respondents were aged between 18 and 30 years, while other respondents were within the age categories of 18 years or below (3.5%), 31–40 years (16.5%), and 41 years or above (31.8%). The majority of the respondents (85.1%) were Xhosa-speaking people while the rest were non-Xhosa. More than half of the respondents (58.1%) had obtained tertiary education, while 27.8 and 5.5% had only primary and secondary education respectively. Only 8.6% of the respondents had no formal school education (other).

Consumers' Perceptions of Beef Quality and Consumption in Eastern Cape Province

The results of the deposition of respondents to beef consumption are shown on Figure 1. The majority of the respondents (89%) were beef eaters while 11% do not eat beef based on various reasons. Of the 89% of respondents that were beef consumers, 44.5% were men and women. In addition, out of the non-beef consumers, 1% claimed to be vegetarians, 5% linked their decision to an allergic reaction, and the remaining 5% attributed their reason to cultural beliefs and personal preferences. A similar result on beef consumption among consumers has been reported in Ghana, Tanzania, and Nigeria (Nandonde et al., 2013; Osei-Asare and Eghan, 2014; Okoronkwo et al., 2020). Preference for beef could be attributed to its role as the first-choice meat for social, religious, and cultural functions in the Eastern Cape and other parts of Africa. This preference for beef is not limited to a province in South Africa but has been reported as the highest consumed meat type in Africa (Guerrero et al., 2013; FAOSTAT, 2014). On the other hand, our results further agree with the findings of Smil (2014), who reported that < 4% of Western society populations are vegetarians (non-meat eaters).

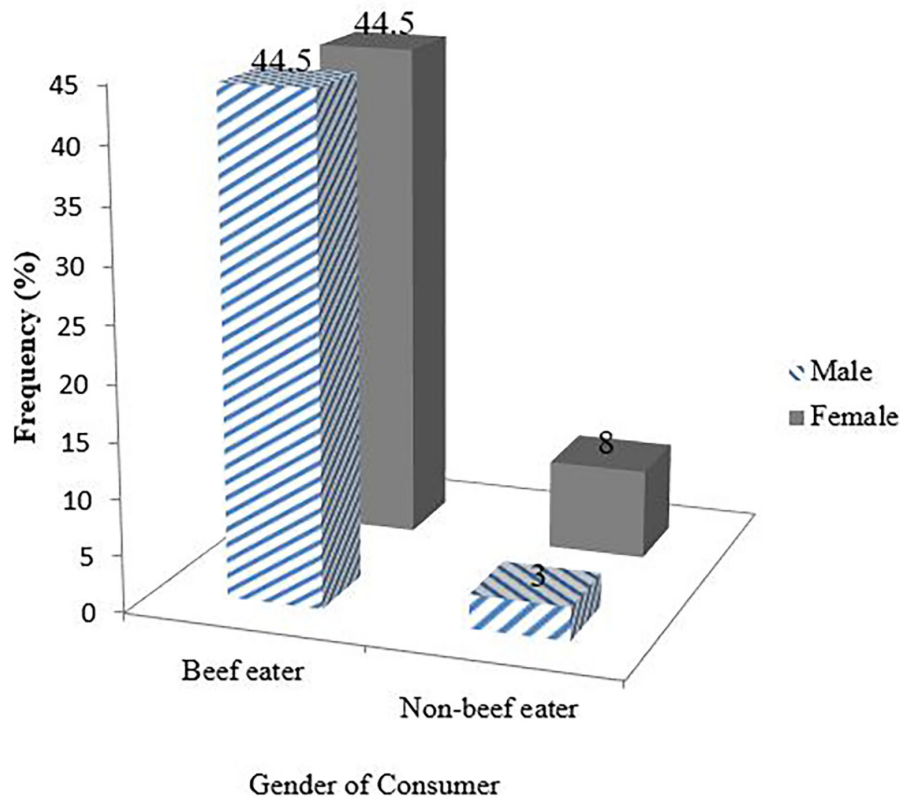


FIGURE 1 | Effect of gender on consumption of conventional beef in the Eastern Cape province of South Africa.

The proportion of participants that indicated allergic reactions after eating beef in this study is in line with the reports of Sampson (2004) and Hong and Vogel (2010), who found that food allergies, such as meat, only affect < 4% of the adult population in the United States. However, different symptoms, such as itching, skin rash, headache, coughing, and throat swelling were reported by the respondents as a consequence of allergic reactions after eating beef and other red meat products. Saleh et al. (2012) reported that allergic reactions are caused by the presence of alpha-gal (oligosaccharide) in beef and other red meat. Following the consumption of beef, the alpha-gal activates T helper 2 (Th2) and causes induction of interleukins, leading to the formation of IgE antibodies by B cells and this, in turn, culminates in mast cell activation, eosinophilia, and hypersensitivity reactions in predisposed individuals. In contrast, Alexander and Cushing (2011) and reported that the association of beef consumption to health risks may be confounded or modified by other dietary factors (such as, high intake of refined sugars and alcohol, or low intake of fruits and vegetables) and/or behavioral factors (low physical activity and smoking) rather than the consumption of beef and other red meat. Conversely, there has been no concrete/conclusive evidence that moderate consumption of beef has negative health effects on consumers (Van Wezemae et al., 2010; Wyness et al., 2011). The result on factors influencing the purchase of beef clearly showed that freshness/color and price were the most quality dictators when

purchasing beef market (Figure 2). Very few consumers purchase beef in relation to its source or fat content. The results from the present study agree with those obtained by Robbins et al. (2003), McCarthy and Henson (2004), Jocumsen (2005), and Predanocytová et al. (2019), who found freshness, color, and price as most important factors dictating the purchase of meat in shop and butcheries.

Consumers' Perception Toward Their Knowledge of Cultured "in vitro" Beef Production

As presented in Table 2, the result revealed that 63% of the respondents (26.7% male and 36.1% female) have not heard about the idea of cultured beef production ($p < 0.05$). Most respondents living in the university community were found to be more conversant with the idea of cultured beef than those from urban and rural areas ($p < 0.01$). These could be attributed to a number of factors, such as inadequate media publicity and access to current information on innovative products. Although, Goodwin and Shoulders (2013) reported that consumer awareness and information/media coverage on cultured meat are still in their infancy. Therefore, a proactive communication scheme for the production of *in vitro* cultured beef would be necessary to create more awareness on the importance for future benefits. This in turn could allow the agricultural industry to have greater

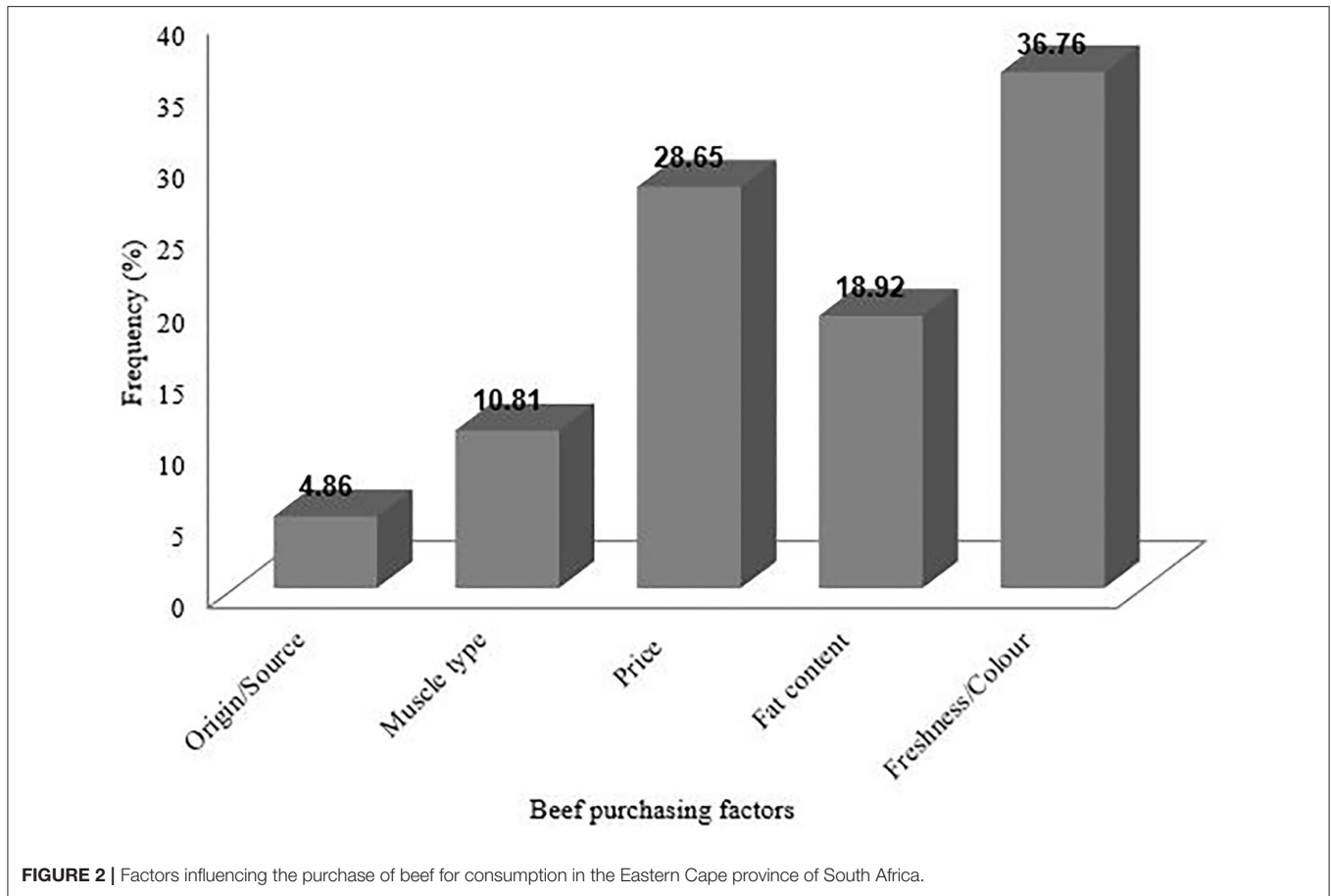


FIGURE 2 | Factors influencing the purchase of beef for consumption in the Eastern Cape province of South Africa.

TABLE 2 | Consumer awareness on cultured beef production in Eastern Cape Province of South Africa ($n = 255$).

Variable	Group	Yes (%)	No (%)	No response (%)	<i>P</i> -value
Gender	Male	20.8	26.7	–	0.018
	Female	15.3	36.1	1.0	
Location	University	23.1	16.1	0.3	0.001
	Urban	5.1	20	0.7	
	Rural	7.8	26.7	–	
Total		36.0	63.0	1.0	

influence in shaping consumers' perceptions on its production (Goodwin and Shoulders, 2013; Bryant, 2020).

After explaining the concept and production of cultured beef (*in vitro* production), 53.1% of the respondents endorsed the production of cultured beef and indicated their interest to eat cultured beef if offered to them (Figure 3). Out of the 53.1% of the respondents that were interested in eating cultured beef, 29.3% were men and 23.9% were women ($p < 0.05$). In addition, a greater proportion of the consumers that showed interest in the consumption of cultured beef resided in university and rural community (Figure 4). This finding

is consistent with the findings of Bryant et al. (2019), who reported that 64.6% of their respondents in their study are willing to eat cultured meat when available. Goodwin and Shoulders (2013) also found in their study that "If cultured beef tastes like conventional meat, and is available in the supermarket people will buy it." However, there were some consumers who expressed doubt and fear about the originality, taste, healthiness, and edibility of cultured beef if provided. In particular, most respondents from the urban community mentioned that the concept of cultured meat is ridiculous and seem unnatural. Hocquette et al. (2015) and Chriki and Hocquette (2020) in their study have shown that some consumers would not accept cultured beef if offered to them because they perceived it is unnatural. In reality, it is natural that some people could be afraid of eating food that they have never tasted before. Moreover, the credibility of cultured beef has been ascertained after a sensory evaluation was conducted in London in August 2013. The panelist reported that the hamburger cultured beef tasted juicy, delicious, and comparable to conventional beef (Zaraska, 2013). Furthermore, evidence has shown that a majority of people will support the production of cultured meat if it is healthy and safe (Haagsman et al., 2009; Goodwin and Shoulders, 2013), such as vegetarians and environmentalists, since its production will eliminate any cruel

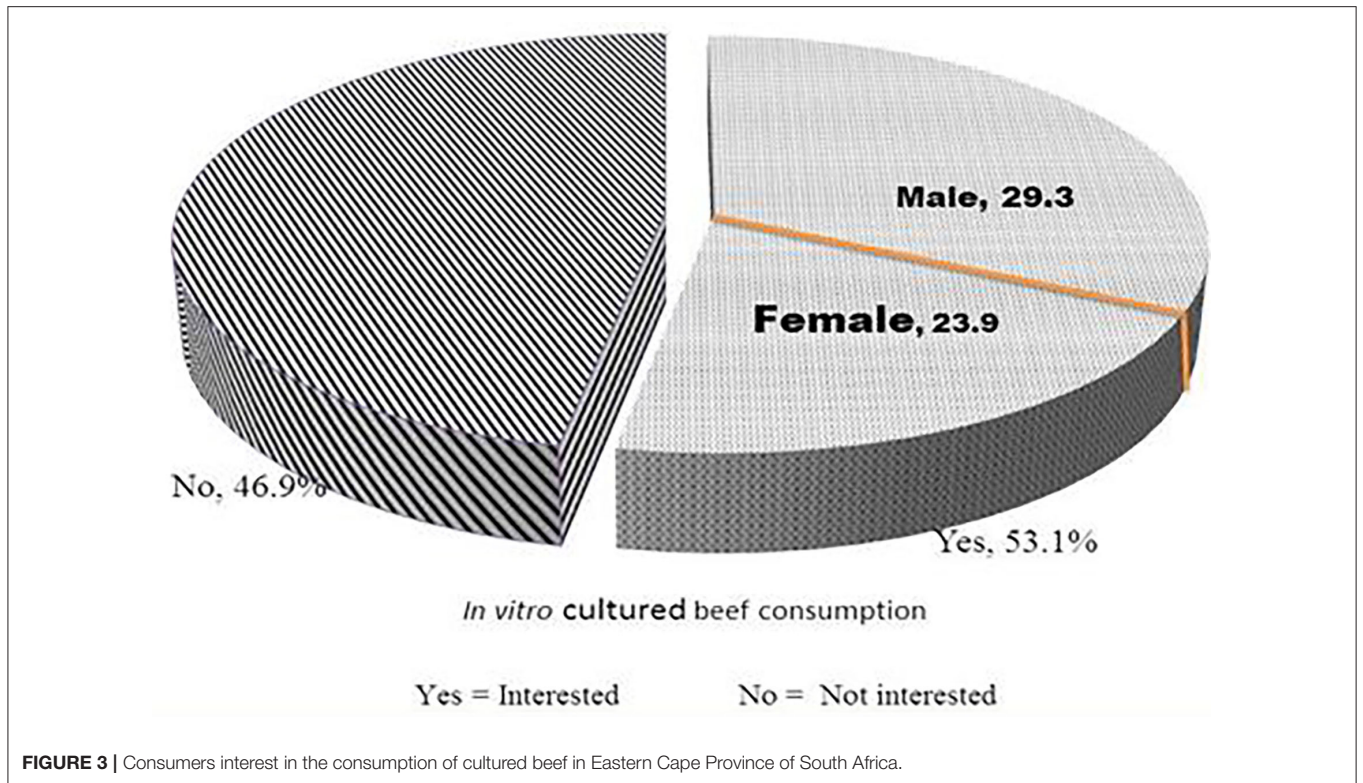


FIGURE 3 | Consumers interest in the consumption of cultured beef in Eastern Cape Province of South Africa.

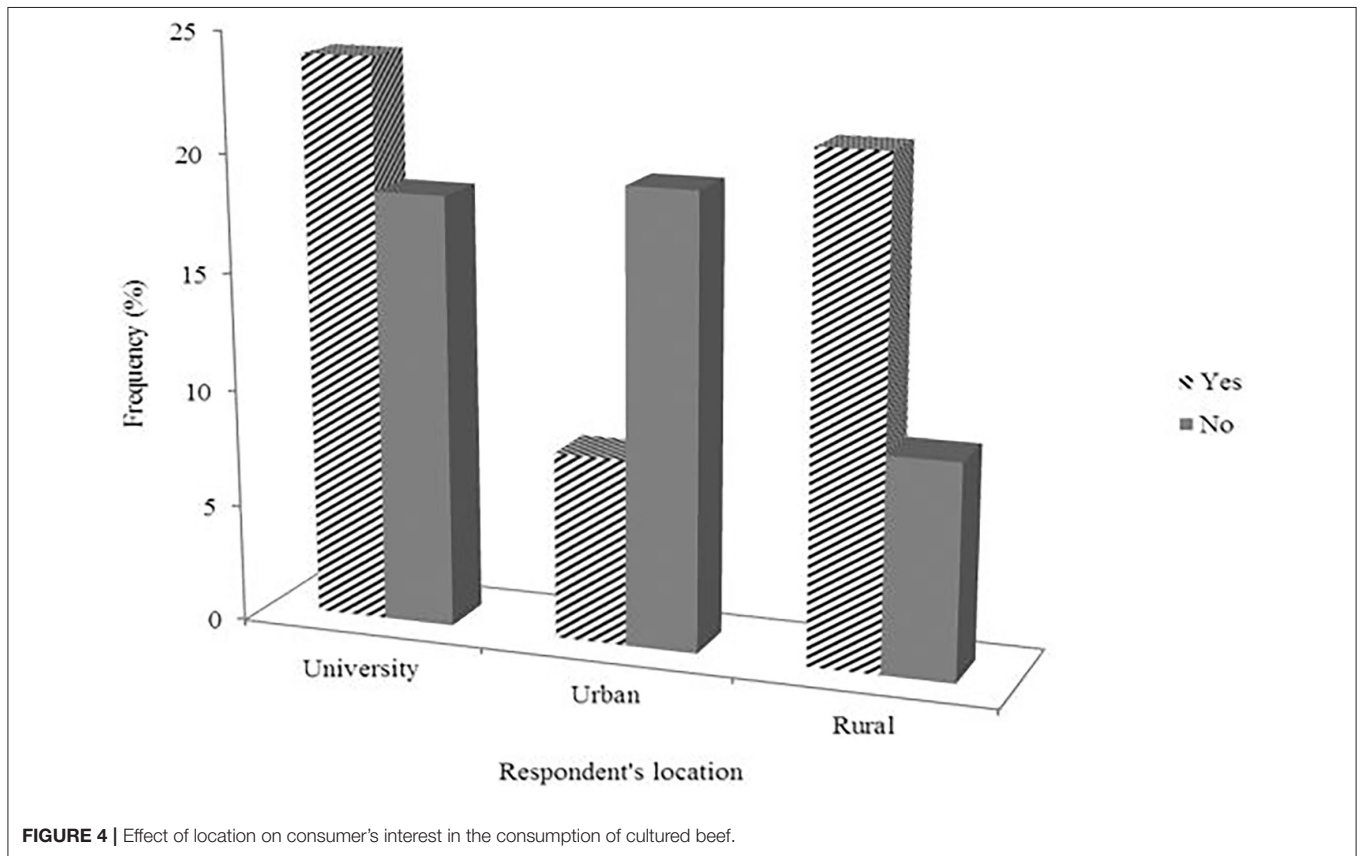


FIGURE 4 | Effect of location on consumer's interest in the consumption of cultured beef.

TABLE 3 | Effect of demographic factor on consumption of beef in Eastern Cape Province of South Africa.

Variable	χ^2 - value	P-value
Consumption of conventional beef		
Gender	9.778	0.973
Age	10.119	0.341
Education	15.472	0.078
Tribe	1.986	0.575
Location	3.520	0.172
Consumption of <i>in vitro</i> cultured beef		
Gender	6.506	0.038
Age	11.316	0.079
Education	82.909	0.001
Tribe	16.754	0.001
Location	23.561	0.001

or suffering associated with factory farmed animals (Schaefer and Savulescu, 2014). In addition, other researchers have shown that the production of cultured beef will improve the biochemical composition of meat and reduce public concern about animal welfare, greenhouse emissions, foodborne disease, and biodiversity loss (Edelman et al., 2005; Datar and Betti, 2010; Canon, 2011; Goffman, 2012; Chriki and Hocquette, 2020). Furthermore, the willingness displayed by some of the respondents to eat cultured beef when commercially available also gave them the assurance that its production would enhance meat production.

In **Table 3**, consumers' willingness to eat cultured beef was observed to be strongly influenced by their educational status among other demographic factors. This probably suggests the need for more proactive orientation to create more awareness on the importance of cultured meat to meat production across the world and especially among people living in developing countries.

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CONCLUSIONS

Findings from this present study revealed that beef is commonly consumed by the majority of people in the Eastern Cape Province of South Africa. Most of the consumers were willing to eat *in vitro* cultured beef if provided. The idea that people would purchase *in vitro* cultured beef does not seem overly implausible. Moreover, consistent information on the benefits, originality, and edibility of cultured meat should be communicated to the public at large to reinforce its production to enhance meat production. More people in the study area are now getting aware of the possibility of producing *in vitro* meat from the laboratory. The study has limitations that should be addressed in future research. The geographical limitation (i.e., the study was conducted in a province in South Africa) is the most noticeable. To our knowledge, this study is the first to examine the perception of meat consumers on the concept and production of cultured meat in Africa. Therefore, further research should also be conducted in other countries in Africa to obtain a broader view and perspective of consumers on the concept of cultured meat.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethics review and approval/written informed consent was not required as per local legislation and institutional requirements.

AUTHOR CONTRIBUTIONS

BF: conceptualization, data curation, analysis, and writing—original draft. BF and EI: visualization and manuscript editing. YH: logistics and supervision. EI: original writing. All authors contributed to the article and approved the submitted version.

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