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Perception towards Cultured Meat: A Survey of Potential Consumers in India

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ABSTRACT

Meat is an important component of the food basket of India and it plays a critical role in meeting protein demand and ensuring the nutritional security of the ever-growing population. Concerns related to environmental impact, shrinking resources, and animal welfare issues continue to haunt the meat industry. Cultured meat on the other hand promises to produce meat without the need to rear the livestock by utilizing fewer resources with minimum impact on the environment. Here, an effort has been made to capture the perception of Indian consumers towards cultured meat by conducting a survey. Results of the survey revealed that about 60.52% of the respondents are willing to buy the cultured meat if made available. It was found that 45.9% of the respondents who are willing to buy cultured meat are ready to pay a premium price range between 10-30%. Among the respondents, 54.0, 59.1 and 66.5% opinedthat cultured meat is a potential alternative to traditional meat in view of challenges like sustainability, nutritional security, and animal welfare, respectively.

***Key words*:** Meat; Cultured meat; Consumer perception; India; Consumer research; Survey

INTRODUCTION

Demand for meat and meat products is rapidly raising around the world including India due to ever growing population, raising standard of living and urbanization. But the issues related to environmental impact of livestock and meat production are a cause of concern in view of emerging climate change challenge. Livestock production contributes to global warming through emissions of greenhouse gases such asammonia, nitrous oxide, methane and carbon dioxide(Giampiero et al. 2019).Among these nitrous oxide, methane and carbon dioxide contribute significantly towards global warming (Lesschen et al.2011). As per Gerber et al. (2013), livestock produces approximately 18% of all greenhouse gas emissions including 37% of all methane emissions, mainly associated with ruminants. Fiala

(2008) estimated that under the Confined Animal Feeding Operations (CAFOs)system, meat production in the future will still be a large producer of greenhouse gases, accounting for up to 6.3% of current greenhouse gas emissions in 2030. Further, indiscriminate use of antibiotics inlivestock production is a significant contributor to increasing drug-resistant pathogen strains (Timothy et al. 2012). There also arise the risk of animal-borne diseases such as bovine spongiform encephalopathy, swine and avian influenza (Vleeschauwer et al.2009) due to human association with livestock.Due to the scale of environmental, ethical and human health impacts of the global livestock industry, it has come under increasing scrutiny in recent years (Scollan et al. 2011). These issues coupled with estimates that demand for animal protein products will continue to rise over the coming decades (Gerber et al. 2013) call for alternative meat production methods which are more sustainable, animal and environment friendly.

Cultured meat (CM), also known as lab grown meat or *invitro* meat or clean meat, is slated to be the potential alternative to traditional meat production. CM is produced by multiplying muscle stem cells (embryonic myoblasts or adult myosatellite cells) extracted from biopsy of the animals in a suitable media (Sharma et al. 2015).Under favorable conditions, the muscle stem cells multiply and fuse to form myotubes and build muscle fibres. Muscle fibres cultured in large quantity are separated from media, pooled and processed to form meat products (Bhat and Fayaz 2011).Tuomistoand de Mattos (2011) compared cultured meat to conventionally produced beef, sheep, pork and poultry, where they estimated that cultured meat approximately leads to 78-96% less greenhouse gas emission, 99% less land use, 82-96% less water use, and 7-45% less energy use, depending upon the type of meat product as compared to that of conventional meat production systems.Majraand Gur (2009) indicated that India must be concerned about the climate change problems which can lead to heat wave, floods and disease outbreaks endangering the life of one of the largest populated countries in the world. In this background, cultured meat is significant as India's response to climate change and also to feed the ever growing population in the decades to come.

InclinationtowardsCM got impetus with demonstration of proof-of-concept by Mark Post, **University of Maastricht, Netherlands** in 2013. This created a sense of possibility among researchers and consumers. Consequent to this several researchers tried to understand the attitude of consumers towards cultured meat in different countries likeNew Zealand (Tucker 2014),European Union countries (Verbeke et al. 2015a), United States of America (Wilks and Phillips 2017; Laestadiusand Caldwell 2015), United Kingdom (O'Keefe et al.2016), China, Ethiopia &Netherlands (Bekkeret al. 2017),Switzerland (Siegristand Sutterlin 2017), Belgium (Verbeke et al. 2015b), Italy (Mancini andAntonioli 2019), China, India and USA (Bryant et al. 2019) while Hocquette et al. (2015) recorded the responses from consumers of various countries spread across multiple continents. However, studies on attitude of consumers focused exclusively on India towards cultured meat have not been reported. Being the second most populous country in the world, attitude of the consumers of India is relevant for firms and researchers involved in cultured meat production and this work is aimed to fill this gap.

MATERIALS AND METHODS

The perception ofIndian consumers towards cultured meat was studied through online and offline survey. The title of the survey wais "Questionnaire for Eliciting Information on Acceptability of Cultured Meat among Consumers". The questionnaire was designed as per the format of Mancini and Antonioli(2019) and Wilks and Phillips (2017) with suitable modifications.

Respondents for the survey

A total of 504 participants were included in this study. This sample comprises of all categories of age, gender, education and income.

Questionnaire for the survey

The questionnaire comprised36 questions. Initially, a brief information about the cultured meat was provided to make consumers aware of the context (Online Resource 1). A pictorial representation of the cultured meat production was also sharedwith the participants of the survey (Online Resource 2). The questionnaire initially asked about their name, age, gender, education level, income level, place of residence and job profile (Online Resource 3). Other questions of the questionnaire were multiple options type to make it easier for the participants to respond. Questions covered different aspects like food habits (vegetarian or non-vegetarian), awareness about the CM, source of their information (newspaper or internet), willingness to engage with CM, willingness to buy CM and amount the respondent is willing to pay to buy CM. Further, questions related to necessity of CM like security, sustainability and animal welfare were asked. The questions related to perception towards CM had options with 5 point Likert-scale includes Definitely No/Much less (5) to Definitely Yes/Much more

(1). Also, the participants were asked for their agreements with the statements about CM with options on Likert Scale basis strongly agree (1) to strongly disagree (5). To know their perception in words a final question as follows"What is your opinion about production of CM?" has been included. This option gave them the liberty to express their opinion in detail.

Statistical analysis

SPSS 23.0 version was used to perform statistical analyses. During the course of analyses, Pearson Chi-square test was applied to determine the association between different categorical variables that include age, gender, education, income and consumer type of response for willing to buy cultured meat. Also, Fisher's exact test was employed appropriately. Logistic regression analysis was performedto determinethe relation between dependent and contributing independent variables along with the Odds ratio and Confidence interval.

RESULTS AND DISCUSSION

Demographic distribution of the respondents

Total respondents (N)of the survey were 504, of which, 63.1% were males and 36.9% were females. Our sample predominantly consisted of young population, with 25.6% below 25 years and 58.73% between 25-45 years. Most of the participants were educated with 30.8% being graduates and 38.5% being post-graduates. Sample group consisted of 84.7% non-vegetarians and 15.3% of vegetarians.The study of Verbeke et al. (2015a) included only non-vegetarians in their survey in European Union. India is predominantly a non-vegetarian country with about 71% of the population being non-vegetarians and about 29% being vegetarians (Government of India 2014). Moreover, the questionnaire included several environmental and animal welfare issues in general, hence, the vegetarians were also included in this study to know their perspective towards CM as an animal and environmental-friendly alternative for meat production. Among the non-vegetariansof this survey, 46.8% consume meat only once a week, 34.9% consume two to three times a week and 18.3% consumemore than 3 times a week. Traditionally, people in India eat foods based on grains and vegetables, and consume limited amount of meat products which is indicated by the fact that per capita consumption of meat in India is about 5 kg/person/annum (Subramaniam et al.2014). The meat of chicken was preferred by 96% of the non-vegetarians in the survey, mutton by 62% and chevon by 56% (Table 2).Chicken is the highly preferred meat in India and it constitutes about 50% of the total meat consumed in the country. Earlier reported study by Bryant et al. (2019) conducted in India along with China and USA (N=3,030) included participants from predominantly high income group while our study covered different income groups where 54% of the respondents were of middle income group categorywith income of less than 5,00,000 INR per annum.

Consumer awareness on cultured meat

Our survey results revealed that 66.7% of the participants were aware of CM, of which 30.6% of the participants came to know about the CM through internet, 8.3% through newspaper and 27.8% through both internet and newspaper(Online Resource 4). In a study by Verbeke et al. (2015b), in Belgium 49% of their population had heard about CM.Media is the major disseminator of information and the major awareness creator regarding cultured meatin India. Media finds the concept of lab grown meat fascinating and is giving widespread coverage to the concept as a technology which can disrupt the traditional production practices.

Consumers' willingness to try cultured meat

Questions were asked to elicit information on willingness to engage with CM. Majority of therespondents(58.7%) are more inclined to try cultured meat while only 19.4% are not willing (probably no or definitely no) to try CM.Whereas 21.8% of the respondents were unsure, which may be because the technology has not been demonstrated completely and the finer details of their mode of production is still unknown (Fig. 1a). Willingness to eat regularly and CM as a replacement to the farmed meat was 35.7% and 38%, respectively in our study. In a study conducted by Mancini and Antonioli (2019), 54% of the participants in Italy were willing to try cultured meat. Whereas in a US based study conducted by Wilks and Phillips(2017), two third of their sample were willing to try CM, but only one third were willing to eat regularly or as a replacement for farmed meat. In case of willingness to eat CM compared to soy substitute, 36.6% of therespondentsin the present study preferredCM over soy substitutes (Fig. 1b). When it comes to the willingness to pay premium price, only 16.8% were willing to pay more price compared to farmed meat and 38.6% are willing to pay less and 37% preferred neither more nor less.

In a study by Verbeke et al.(2015b), only 9% of the consumers rejected the idea of trying cultured meat, while two thirds hesitated and about a quarter indicated to be willing to try it. When provided the additional information about the environmental benefits of cultured meat compared to traditional meat, 43% of the participants were willing to try this novel food, while another 51% were unsure.Contrarily, in a study by Tucker(2014), 55% of the participants were opposed to *in vitro* meat, 32.5% were favorable, and remaining 12.5% had mixed feelings about it. Slade (2018) has performed ahypothetical choice experiment where the consumers were asked to give their opinion on willingness to purchase three types of burgers each made of beef, plant-based protein and cultured meat. The consumers said that all burgers tasted the same, and they preferred beef burger over others. If the price of three burgers were equivalent, only 21% of consumers would choose the plant-based burger, and 11% would choose the cultured meat burger.

Table 1. Willingness to eat farmed vs cultured meat

Type of meat	Farmed meat	CM	Difference
Chicken	410(96)	290 (68)	-28**
Mutton (sheep meat)	264 (62)	204 (48)	-14*
Chevon (goat meat)	238 (56)	159 (37)	-19**
Beef	33 (8)	33 (8)	0
Buffalo meat	19 (4)	17 (4)	0

** indicate statistical significance at P<0.01 and * indicate p<0.05

Preference of meat species for CM

The respondent's preference for meat derived from different speciesfor producing CM was collected(Table 1). Chicken is found to be the most preferred meat for both farmed (96%) and cultured source (68%). In India, meat consumption in particular is determined by the religious beliefs wherein pork is a taboo to Muslims while beef is a taboo to Hindus, which makes poultry a highly accepted meat. Further, there is high consumer demand for chicken in India due to perception that poultry meat is healthier than other meats (Subramaniam et al. 2014). About 48% of the respondents wished to get CM of mutton while 37% wished to get CM of chevon.Interestingly, beef and buffalo meat were preferred by only 8 and 4% of the respondents, respectively. This is because of the restrictions on production and consumption of beef in India owing to religious beliefs. Further, about 80% of the total buffalo meat produced is exported making India the top buffalo meat exporter in the world. Domestic demand for beef and buffalo meat is very less in India. Hence, chicken meat followed by mutton and chevon holds good potential for commercial cultured meat production.Very few respondentswished to get CM ofother meat species like deer, rabbit, tiger etc.In a study by Wilks and Phillips(2017), some of the respondents expressed their interest to try unconventional meat species such as horse, cat, and dog along with conventional meat (poultry, pork, beef, and fish).

Willingness to buy cultured meat

In our study 60.5% respondentswere willing to buy CM (Table 2) while in the study reported byMancini and Antonioli (2019) 44% of the respondents were willing to buy cultured meat.Bryant et al.(2019)reported that 29.8, 59.3 and 48.7% of the consumers in USA, Chinaand India, respectivelywere extremely likely to purchase cultured meat.The age and gender of the respondents did

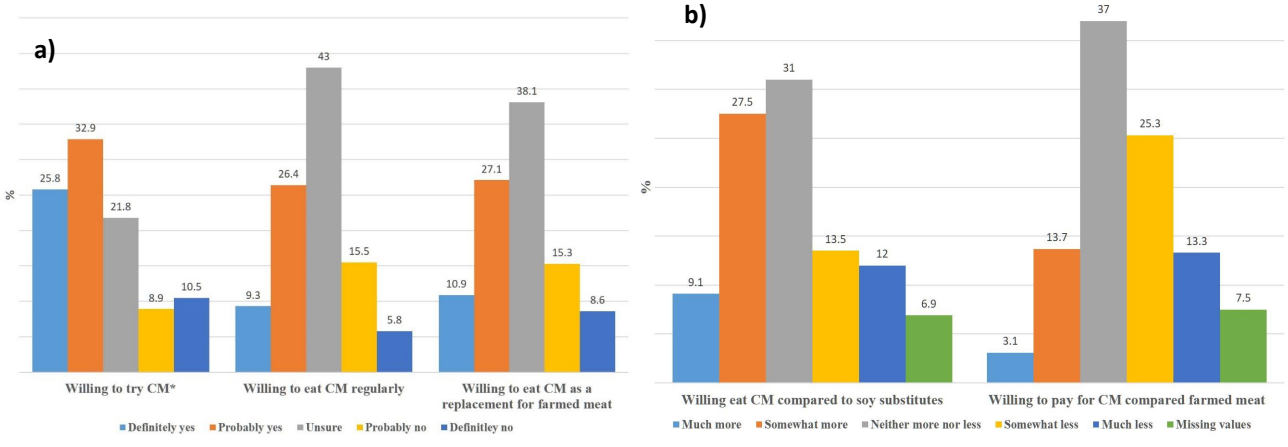

Fig.1. Participants willingness to engage with cultured meat A) willing to try, willing to eat CM regularly, willing to eat CM as a replacement to farmed meat. B)Willing to eat CM compared to soy substitutes, Willing to pay more for CM compared to farmed meat (*indicates those who said yes to willing try CM only included for analysis in later questions)

not significantly affect the willingness to buy CM (Table 2). Level of education significantly affected the attitude of consumers towards cultured meat, where highly educated were more open to the idea of CM and were willing to try. When the income level isconsidered, participants with annual income below 5,00,000 INRwere more willing to buy CM. Among the consumers, about 70% of the non-vegetarians were more willing to buy CM while about 18% of the vegetarians were willing to try CM. This indicates that, CM can be a potential option for vegetarians who are averse to meat harvested from animals.

Willingness to pay premium price for cultured meat

Price of meat is an important factor for its acceptability among consumers and both the factors are inversely proportional (Demirtas 2018). In our study, among the consumers willing to buy CM45.9% are ready to pay premium price (10 to 30%)while42.3% were willing to pay10 to 30% lesser price compared to traditional meat(Online Resource 5).Wilks et al.(2017) reported 16% consumers' willingness to pay a premium price for CM. Without the awareness regarding CM, 14% respondentsshowedwillingness to pay a premium price for CM, while the percentage increased to 36% when the respondents were informed about the benefits of CM (Verbeke et al. 2015a). In a sensory study by Rolland et al.(2020), 58% of therespondents were ready to pay on an average 37% higher the price of farmed meat for cultured meat.

Gender perception towards cultured meat

When the gender specific (male and female) responses for eleven questions related to cultured meat were analyzed,statistically significant difference was found for two questions:(a) CM is a viable alternative to farmed meat and (b) CM will reduce the global warming associated with farming (Online Resource 6). For these two questions, women were found to be more positive than men. Contrarily, in the reports by Wilksand Phillips(2017) and Mancini andAntonioli(2019), men were found to be more willing to engage with CM than women.

Table 2. Willingness to buy (WTB) cultured meat by various categories of respondents

Category	Divisions	WTB-yes		WTB-no		Total	Total Chi- square	p-value
		N	%	N	%			
Gender	Male	196	64.05	110	35.95	306	0.84	0.39(NS)
	Female	109	59.89	73	40.11	182		
Age	<25	79	62.70	47	37.30	126	0.44	0.93(NS)
	25-45	181	63.07	106	36.93	287		
	45-60	39	59.09	27	40.91	66		
	>60	6	66.67	3	33.33	9		
Not Highly educated	None	2	66.67	1	33.33	3	7.1	P<0.05
	Primary School	2	66.67	1	33.33	3		
	High School	10	90.91	1	9.09	11		
Highly educated	Intermediate	20	80.00	5	20.00	25		
	Graduation	90	60.40	59	39.60	149		
	Post-graduation	116	61.70	72	38.30	188		
	PhD	65	59.63	44	40.37	109		
Income	<5 Lakhs	184	68.40	85	31.60	269	9.2	P<0.05
	5 to 10 Lakhs	75	55.56	60	44.44	135		
	10 to 20 Lakhs	35	56.45	27	43.55	62		
	>20 Lakhs	11	50.00	11	50.00	22		
Consumers	Veg	13	17.57	61	82.43	74	74.9	P<0.001
	Non-Veg	292	70.53	122	29.47	414		
Total	Overall	305	60.52	183	36.31	488		

Attitude towards cultured meat

In the present study, majority of the respondentsagreed that the CM is not against nature, can improve animal welfare conditions, doesn't reduce the number of happy animals and will notencourage the possibility of cannibalism (Table 3). For some statements such as ethical, unnatural, CM's ability to solve world famine problems, to be an alternative to farmed meat, to impose negative impact on traditional farmers and ability to reduce the impact of global warming associated with farming; the participants were neutral *i.e.,* they neither agree nor disagree. This may be because of lack of information on production practices and the associated risks involved.Verbeke et al. (2015a) surveyed the reaction of consumers in three EU countries regarding cultured meat and reported that the initial reaction of consumers was that of disgust but they could connect to the perceived social and environmental benefits put forth to justify cultured meat production. Contrarily, in aglobal study (n=1890) conducted by Hocquette et al. (2015) majority of the educated consumers while agreeing that meat industry is facing important problems due to protection of environment, animal welfare and inefficient production system; did not believe that cultured meat can solve the mentioned problems. Despite these limitations, 38 to 47% of the respondents supported the research in cultured meat. In a study by Wilks and Phillips(2017), majority population felt CM can be more environmental friendlywith less risk of zoonosis compared to farmed meat, but they opined thatCM isless natural, less appealing, and less tasty than farmed meat. The participants on an average, disagree with the statements such as CM was disrespectable to nature or that it would reduce the number of happy animals on earth and agree with statements that it would have negative effects on traditional farmer and it might increase the possibility of cannibalism. However in a study by Mancini andAntonioli(2019), participants showed higher agreement with the statements concerning positive externalities (sustainability, animal welfare and security) than the intrinsic characteristics (safety, flavor and nutrients) of CM. In this study as well the respondents agreed to the statements mentioned except the intrinsic characteristics such as flavor and nutrients. In a study conducted with participants from three different countries*i.e.,* China, Ethiopia and Netherlands, the Chinese and Dutch participants were found to be more positive with CM due to promise of improved animal welfare, environmental benefits and food security(Bekkeret al. 2017). In comparison to Chinese participants, both Dutch and Ethiopian participants felt cultured meat as fake, unnatural and non-organic. In a study by Siegristet al.(2018), the participants considered the conventional meat as more natural compared tothe cultured meat and their results indicated that the experimental manipulation influenced the participants' opinion regarding CM naturalness that subsequently evoked disgust affecting the willingness to eat meat. In the study by O'Keefe et al. (2016) majority of theparticipants(vegetarians and non-vegetarians)considered CM to be animal friendly as meat is available without the need to sacrifice the animal.

Cultured meat in vegetarians' perspective

In this study, 15.3% of the total respondentswere non-meat eaters and categorized them as vegetarians (Online Resource 7). While in an Italian based study by Mancini andAntonioli(2019), only 8% of their sample were non-meat eaters comprising mainly women (80%) and in astudy by Wilks and Phillips(2017), there were 2.8% vegetarians in their population. Our respondents statedvarious reasons for not eating meat which includedfood habit of their community/ religion, cost, compromise of animal welfare in intensive livestock production, natural resources depletion due to livestock production and inherent dislike to eat meat.It was observed that 19.5% of the vegetarian respondents were willing to try CM, 19.5% of them were unsure and 61.1% of them were not willing to try CM.With regard to type of CM, 24.7% of them preferred chicken, followed by mutton (5.2%), chevon(3.9%)and fish (2.6%). Vegetarian respondents had positive opinion about CM that it would improve the animal welfare conditions.

Perception on CM attributes

In the present study, 46.6% of the respondents agreed to the safetywhich is an intrinsic attribute of CM, while 14.3% disagreed and 39.1% remained neutral. The poor public perception about the safety of CM could be due to the lack of detailed production methodology. Hence, it is imperative to develop detailed standard production techniques of CM and create awareness among public. More than half of the respondents agreed to the extrinsic attributesof CM such as sustainability, security and animal welfare. Similarly, in an Italy based study by Mancini and Antonioli(2019) the respondents had better perception of extrinsic attributes of CM than intrinsic attributes. In USA,27% of the consumers raised environmental concern and24% about animal welfare,when questioned regarding meat substitutes like CM (FMI, 2020).

Table 3. Agreement with statements about consumer perception towards cultured meat (1 stronglyagree—5stronglydisagree)

Statement	Mean	SD
CM is unnatural	2.54	0.955
CM is disrespectful to nature	3.25	0.99
CM will reduce the number of happy animals on earth	3.35	1.023
CM will encourage the possibility of cannibalism	3.27	1.056
CM is ethical	2.75	1.005
CM will improve animal welfare conditions	2.42	0.919
CM will be able to solve world famine problems	2.62	0.98
In the future, CM will be a viable alternative to farmed meat	2.58	0.923
CM will reduce the impact of global warming associated with farming	2.56	0.989
The production of CM will have negative impacts on traditional farmers	2.52	1.073

CONCLUSION

The present study concludes that majority of the respondents are aware of cultured meat and showed willingness to try, if made available. While most of the participants agreed to the positive aspects of CM regarding extrinsic characteristics like sustainability, security and animal welfare;only less than half agreed to the intrinsic characteristic like safety of the CM. Intensive evaluation of CM concerning its environmental advantages, development of standardized regulations and creation of public awareness are pre-requisites for introduction of CM into the Indian market. Further,a comprehensive analysis regarding the impacts of CM on the supply chain may help to establish sustainable CM industry in India.The present study indicates that India can be a good market for cultured meat as and when it is commercially produced due to its huge population base and extent of acceptability of CM among consumers.

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