BİLKENT UNIVERSITY

2021 FALL SEMESTER

GE 301

SCIENCE, TECHNOLOGY and SOCIETY

Cultured Meat: Meet the New Meat

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1. Introduction

Cultured meat also known as synthetic meat or clean meat is developed in a laboratory using animal stem cells under in-vitro (outside of the organism) laboratory conditions. This technology is particularly gaining attention from the public since it is an alternative to the conventional meat that has been regarded as inefficient and unsustainable when ever-increasing production volumes due to large demands are considered and the accompanying carbon footprint of the meat industry. Cultured meat is also subject to a lot of controversy related to animal ethics, health, and safety stated by several stakeholders such as scientists, animal rights activists, and conventional meat producers. Our field site, biftek.co, is a research firm that works on optimizing cultured meat production methods. Their aim is to replace the use of FBS and achieve mainstream status with their product over traditional meat. We have conducted three interviews with the team of biftek.co to examine their work and observe their operations through the lens of responsible research and innovation. An important portion of cultured meat research is focused on making this technology more sustainable, ultimately aiming to become mainstream and ensuring there are no negative impacts on the environment. The cultured meat industry is considered as a potential solution to meet the demand of the increasing world population and combat climate change since its production process is more environmentally friendly and sustainable than traditional meat production. Cultured meat technology is novel and needs more time before becoming a complete alternative to traditional meat; studies suggest it offers a more sustainable, environment-friendly, and cruelty-free alternative protein source.

2. Theory

In this project, Responsible Research and Innovation (RRI) will be used to analyze the state and development of the cultured meat industry. Responsible Research and Innovation focuses on considering and applying the values and concerns of the public to the construction of developing technologies and researches. RRI includes four dimensions that innovators focus on broadening in the development stages of new and existing technologies: anticipation, inclusion, reflexivity and responsiveness. The anticipation dimension is the acknowledgment of possible risks, social and ethical issues that the developing technology might bring. The second dimension is inclusion. The inclusion dimension of responsible innovation refers to involving external opinions and values and different perspectives (van de Poel et al. 701). The reflexivity dimension implies that the responsible innovations should reflect on values and the social and ethical impacts of the technology. The last dimension responsiveness suggests that responsible innovations should be open to reactions and respond to the concerns and the developing events about the technology. Responsiveness can become further crucial when the anticipation about the values and ethical and social issues related to the innovation is not clear. These four dimensions are implemented with 6 lessons of RRI. These six lessons are: Strategize for stakeholder engagement, Broaden current assessments, Place values center stage, Experiment for responsiveness, Monitor RRI progress, Aim for shared value. These six lessons aim to achieve responsible research by understanding the respective social groups of the technology, understanding their values and external views, aligning the values of the company with their values and taking accountability for the social impacts of the technology. These six lessons form the fundamentals for achieving responsible research and innovation ("Introduction to Responsible research and innovation (RRI) and related tools").

3. Background Research

This section has been broadly divided into categories related to technology, public concerns and sustainability that have been further divided into sub-categories.

3.1. Technological Aspects

The cultured meat wave of the past two decades can be divided into two phases. The first phase is more university-based and covers the period from the millennium to around the first cultured burger event in London where it was cooked and eaten in 2013 ("World's first lab-grown burger is eaten in London."). In the second phase, there emerged startups and venture capital (VC) interest to support it ("Making Sense of Making Meat"). One such startup is biftek.co located in Turkey.

3.1.1. Cultured Meat Technology

The history of cultured meat technology can be traced back to 1921, where Alexs Carrel developed a piece of tissue from a cultured embryonic chicken heart in a laboratory. This led to further developments in the cell agriculture domain until 30 laboratories around the world were engaging in cultured meat research in 2012 (Rout et al. 2). Stem cells are isolated from the animal's body and allowed to grow in a cultured medium filled with necessary nutrients (proteins, vitamins, etc) and energy sources, under controlled temperature, pH, percentage of carbon dioxide, growth factors, etc (Rout et al. 3). These cells then gradually develop tubular structures when placed inside bioreactors (Rout et al. 1). Hence, animal products obtained in such a way eliminate the need to raise and slaughter a whole animal just to obtain parts of it.

3.1.2. Technical Challenges

A number of technical challenges related to cell culture media components and an accurate replication of meat exist. Fetal bovine serum (FBS) enhances the growth of cells but

is obtained from cow fetuses, killing them in the process (van der Valk et al). This leads to major ethical concerns. It also raises cost concerns since FBS is a significantly expensive product. A major technical challenge is incorporating the flavors and texture of real meat into cultured meat ("How Lab-grown meat is made") to replicate it well. Today, startups are trying to address these challenges as well as those of developing better cell lines, cheaper culture media thereby reducing the time it takes for cell growth. ("How Lab-grown meat is made") biftek.co is one such startup that is located in Turkey.

3.1.3. Commercial and Consumer Aspects

Cultured meat production comes with its own set of financial challenges. In 2015, the first lab-grown burger cost 325,000 dollars (Mutter). Today, cultured meat is still too expensive to be considered cost-competitive even for a premium product. The pharmaceutical grade approach method produces small quantities of cultivated meat but this needs to be turned into a scalable industrial method to reduce expenses. Scaled-up processes could be considered similar to those seen in the fermentation of beer and cheese ("Cultured Meat: Lab Grown Meat Is Becoming A Reality"). There are challenges related to large-scale production since the key issue is being able to "produce effective and less expensive culture media" ("Bringing cultured meat to market" 4) and "balancing the costs associated with the technologies" (Brown) involved in producing cultured meat.

On the consumer end, participants of surveys have stated that if priced cheaply, they would choose the lab-grown alternative over the traditional one (Bryant and Barnett 13). According to experts, "cell-based meat can be produced at the same cost as conventional meat" (Brown) once production processes have been scaled up. In a news article from Food Navigator, cultured meat prices could be competing with conventional meat prices in about a decade (Watson). Participants of a study stated that they would buy cultured meat if the

environmental and ethical benefits of cultured meat would justify paying the same price as regular meat (Bryant and Barnett 13).

There also exist concerns about the potential end of traditional rural life and unemployment of working-class people (Bryant and Barnett 14). An Australian cattle producer stated that positive environmental claims made by cultured meat researchers are merely propaganda that threatens the future of agriculture sector workers, their families and communities (Wilson). Another group of stakeholders argued that loss of income for livestock producers and farmers could be fixed by transforming them into the cultured meat sector since with the normalization of cultured meat, many new job opportunities could potentially appear in this sector (Moritz et al. 4).

3.2. Public Values and Concerns

3.2.1. Consumer Acceptance

Consumer acceptance is considered to be a major hurdle in the normalization of cultured meat since consumers form the largest population of stakeholders. Factors like strangeness, unnaturalness, health concerns, taste (yuck factor), competitive prices, religion, etc must also be taken into account. According to a survey conducted in Europe, more than half of the participants are willing to try cultured meat. On the other hand, surveys also show that people may reject it because of its unfamiliarity and unnaturalness. This product has been termed a “Frankenfood”, “zombie” and bioengineers have been criticized for “playing God” and “interfering with nature”. However, evidence suggests that being familiar with the production process of cultured meat is the key to increased acceptance (Bryant and Barnett 12). Although some people view cultured meat as clean, safe, and regulated since it was created in a laboratory (Böhm et al. 212), others doubt the healthiness and naturalness of laboratory products (Moritz et al. 55). When people consume meat, they expect good taste and flavors, and textures unique to it. When introduced to the idea of cultured meat replacing

original meat, people expected cultured meat to taste worse than traditional meat. The public also thinks that cultured meat would have an inferior texture or appearance compared to traditional meat (Bryant and Barnett 13). This perhaps originates from the fact that current meat substitutes do not taste as "good" like real meat.

Doubts from the religious communities have been raised about the conformity of cultured meat production to food practices they deem legal in a religious light. A critical point arises from the production method and the religious practices regarding meat consumption. Common religions like Islam criticize in-vitro meat technology since it could not be considered halal and/or will refuse to consume in-vitro meat if pigs are used in production. Although how religious communities would receive clean meat is not very clear, there is a common concern about in-vitro meat technology invading religious practices (Bryant).

Media plays a crucial role in forming public opinions on new food technologies (Bryant). Recent studies show that unnaturalness and safety concerns regarding cultural meat can be invoked or avoided by presenting them differently in the media. The Good Food Institute argues that consumers are more likely to be drawn to the name "clean meat" and find it more appealing than when termed 'cultured meat' or 'cell-based meat' (Bryant and Dillard). European and American media findings are more supportive of cultured meat. A US-based vegan news website stated that around ninety percent of Gen-Z citizens of the US and UK have positive views on cultured meat (Axworthy).

3.3. Sustainability

Cultured meat has strong ties with sustainability for a number of reasons that include sustainable food production, environmentally-friendly practices and combating climate change. The Paris Agreement adopted in 2015 is an international treaty that brings about 196

countries together to not only combat climate change but also adapt to its effects. Implementing the Paris Agreement requires "economic and social transformation based on the best available science" where countries must present their plans every 5 years about reducing global warming ("The Paris Agreement"). To this end, cultured meat production is expected to be more environmentally friendly and have a positive impact in tackling climate change according to ongoing studies. A growing stakeholder community, consisting of scientists and innovators, suggests that cultured meat can meet traditional dietary needs while addressing sustainability goals (Böhm et al. 212). Dr. Carolyn Mattick, who conducts sustainability studies related to lab-grown meat claims that cultured meat is likely to be better than factory farming because of its drastically lower amount of water pollution and land use (Skye). In addition, carbon emissions from the food industry are significantly harmful to the environment. The food industry contributes to almost a third of carbon emissions including livestock as well. This fact is further supported by The Good Food Institute, an NGO that promotes alternative protein, which claims: "a significant amount of greenhouse gas emissions are caused by the livestock sector" ("Lab-grown meat: The future of food? | FT Food Revolution"). These negative effects are expected to increase as the human population increases. In the food industry, from deforestation to transport, waste management to food storage, each step of the food chain brings with it a high carbon footprint. To reach net-zero carbon emissions halfway through the century as dictated by the Paris Agreement on climate change, the food industry must adopt new measures (Brown).

The demand for food is also expected to increase by up to 40% by 2050 which makes world hunger an alarming issue (Elferink and Schierhorn). The parallel increase in demand will also increase the demand for animal-origin meat and dairy foods (Jairath et al. 704). There will be significant challenges to feed the world; especially with "climate change-driven water scarcity, rising global temperatures, and extreme weather" that will be expected to also

severely affect crop yields (Elferink and Schierhorn). There will be fewer land and water resources available in the future with a higher human population. To make sure food production remains sustainable and enough to feed the global population, novel food products must be introduced.

Moreover, current practices of industrial farming lead to diseases among consumers. A large number of antibiotics are given to animals that are then transferred when their meat is consumed. This encourages anti-microbial resistance ("Lab-grown meat: The future of food? | FT Food Revolution"). These drugs, which include additives and steroids, given to animals for faster production are harmful to human beings (Rout et al. 6). The slaughtered animals may also be diseased and the bodies of animals may also not be appropriately cleaned before they are supplied to consumers (Rout et al. 6). With cultured meat, these issues are avoided and the risk of an outbreak of disease is also diminished as cultured meat is not produced from animals that are confined in a small space. Moreover, cell production is halted in case of any contamination of the culture media (Rout et al. 6). In cultured meat production, issues related to disease and contamination can be avoided entirely.

4. Method

The designated field site, biftek.co, was chosen due to its closeness to the key subject that is sustainability. Initially, the executives of the company were e-mailed by the group members to arrange interviews. Three interviews of six questions each were arranged with CEO Kerem Erikçi, CTO Erdem Erikçi and CSO Can Akçalı of biftek.co respectively. The information from these interviews was annotated, and sorted via QDA Miner Lite software. Data specific to the questions were analyzed in light of background research and cross-examining of separate interviews.

5. Findings

5.1. Technical Aspects

According to the information from our interview with the CEO of biftek.co, in the production of cultured meat, muscle stem cells are obtained from animals and placed in a growth medium to divide and reproduce. He explained the use of stem cells in the following way: "Once you get the cell from the cow, you place it into the growth medium and by use of this growth medium, the cell can divide and reproduce itself" (K. Erikçi). It can be seen that stem cells are used as a base to initiate meat production. One of the most common technologies used to produce cultured meat involves the use of Fetal Bovine Serum (FBS). In order to "keep the cells alive and to push them forward to proliferate", growth factors are added (E.Erikçi). In a regular cell culture environment, FBS is used as the growth factor because it contains some proteins that trigger the cells to proliferate. However, the serum is obtained from the blood of an unborn calf and "you have to kill the fetal bovine to be able to obtain it" (E.Erikçi). This quote is crucial as it shows that the FBS method is against the philosophy of cultured meat, and therefore, there is a need to replace it. The stem cells placed in a growth medium and an example of FBS can be seen in Figures 1 and 2 respectively.

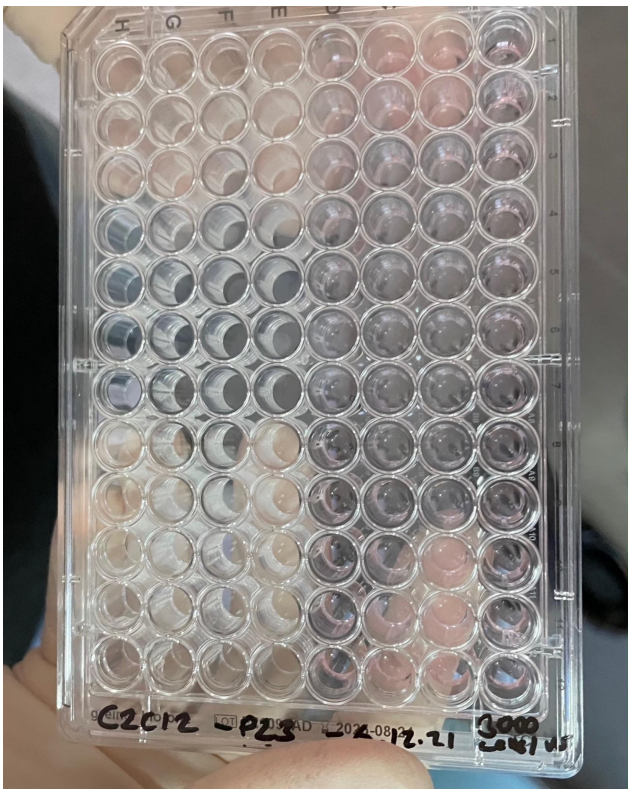

Figure 1: stem cells in growth medium

Figure 2: Fetal Bovine Serum (FBS)

Biftek.co practices a different production method based on micro-organisms - bacteria obtained from different living organisms. Instead of the serum being obtained from the calf, the microorganisms are used to enhance stem cell growth. They are stored in special freezers at -80 degrees Celsius. This special storage ensures that the obtained bacteria can be used again and this eliminates the need to reobtain the microorganism from the source animal. Some words of the biftek.co CSO help demonstrate the reuse of the microorganisms: "when there is another need to use bacteria, the same bacteria is ready to be used again" (Akçalı). Thus, both the necessity of killing a fetal bovine and reobtaining bacteria from animals are eliminated with this technology.

Cultured meat technology is applied in a closed-loop environment. This means it eliminates the contamination factor in production. The CEO claims: “there is no contamination, no bacterias, no food-borne diseases because closed-cycle production does not

allow any kind of contamination" (K.Erikçi). This quote indicates the importance of hygiene in cultured meat production environments. Also, there is almost no antibiotic consumption in this method. As cultured meat technology develops steadily, some prototypes prove that the improvements in the technology are feasible and not likely to fail. The categorized quote examples can be found in Table 1 below.

FBS (Fetal Bovine Serum)	"In a regular cell culture laboratory, FBS (fetal bovine serum) is used to be able to keep the cells alive and proliferate them. It contains the proteins that give them the signal to proliferate. However, it is very expensive and its origin is animal. …it is the blood serum of the fetal bovine. **You have to kill the fetal bovine to be able to obtain it**. And, it is completely contradictory to the philosophy of cultured meat. Therefore, it **must be replaced**." (E.Erikçi)
Use of microorganisms	"We are trying to feed the cells using microorganisms. Although we obtain those microorganisms from animals, we **do not need to go back to the animals to produce further**. We can keep them in -80 degrees Celsius freezers and when we need them we just thaw them and then you know, proliferate those micro-organisms and then obtain their metabolites." (E.Erikçi) "We base our technology on microorganisms, bacteria. After the bacteria is used, it is preserved in special fridges, when there is another need to use bacteria, **the same bacteria** is ready to be used again." (Akçalı)
Use of antibiotics	"There is almost no antibiotic consumption." (K.Erikçi)
Feasibility of the technology	"Maybe the technology will never be mature enough to produce large quantities. So the upscaling may fail but it is not very likely because there are already **some prototypes** that prove this is going to be **feasible**." (E.Erikçi)

Table 1

5.2. Social Aspects

According to the biftek.co CTO, the stakeholders include anyone who is interested in meat. Interested parties also include food producers since cultured meat is considered as ‘next-generation’ food. The quote from the CTO may be effective at demonstrating that the general public is the stakeholders: "Anyone who is consuming meat would be interested"

(E.Erikçi). Moreover, the CEO claimed that they are approached by meat companies with regard to sustainability and financial issues. They struggle to keep up with feed prices, climate change, drought, and agricultural burdens. Hence, they are reluctant to raise any cows or chickens, etc. for meat production. When thinking of conventional meat, cowboys, villagers, or farmers come to mind but as food technology advances, scientists are taking their places. As the CEO stated, "Now things are changing rapidly, scientists are the new farmers" (K.Erikçi). Therefore, the more specific stakeholders could be molecular engineers, genetics, and scientists. On the other hand, some people do not like the concept of meat at all, the taste, smell, the look, and choose to be vegan or vegetarian for that very reason. Others are more interested in climate change, sustainability, animal welfare and adopt veganism or vegetarianism for those reasons. The members of the vegan/vegetarian community who are disinterested in the meat itself are indifferent towards clean meat and traditional meat. However, in general -especially the ones against classical meat production- the vegan/vegetarian community supports the clean meat movement.

When it comes to cultured meat, people are concerned about health issues. However, due to the closed-loop production method, cultured meat production does not allow any contamination, bacteria, or food-borne diseases while there are such risks in traditional meat production. As a response to such concerns, the CEO claimed that “it is at least as healthy as today's conventional meat” (K.Erikçi). Furthermore, he claimed that there is almost no antibiotic consumption in their way of production. Globally, 80% of antibiotics are consumed by animals and when people eat animals, these antibiotics are consumed by them. In China since all kinds of animals are being slaughtered and sold, this has led to the development of new viruses. Examples include the Covid-19 virus, SARS or Swine Flu or Bird Flu, and Mad Cow disease which all arise from disease outbreaks in animals due to poor living conditions in industrial farming. The words of the CEO may help emphasize the health risks of

exploitation of animals: "There is the bat market, all kinds of animals are slaughtered there and this creates lots of viruses which we do not know may harm humans. (…) That's why today you are wearing your masks because we are abusing animals" (K. Erikçi). He also indicated that when meat is produced in a laboratory, these issues cease to exist. This shows that cultured meat can be considered as healthy as conventional meat. According to the information we obtained from our visit to biftek.co's laboratories, they adopt the motto of "If slaughterhouses had glass walls, everyone would be vegetarian" (Paul McCartney). This quote from Paul McCartney is written on the glass door of their laboratory and can be seen in Figure 3.

Figure 3: Glass door of biftek.co laboratory

There are also some concerns among animal rights activists. They can be divided into two groups. One group accepts this technology and the other does not. An example of the group that supports this technology exists in the US called The Good Food Institute. It is a non-profit organization that supports alternative protein. The founder of this institute is a

vegan and so are most of the workers. However, the CTO states that due to the use of FBS, some vegans are against cultured meat technology. His words can help demonstrate the concerns of animal rights activists who oppose this technology: "Some pioneers of veganism are against this technology because of some concerns like this production method involves FBS and some other animal products" (E. Erikçi). Their opinions are valid and must be considered. However, cultivated meat will not be in the market before solving the FBS problem. As the technology develops, and these problems are solved, the CTO believes they will be convinced. Some animal rights activists support clean meat production since it also accepts the idea that animals are not just machines for milk or meat and should not be abused. The CEO indicates the importance of this idea in his words that "they have souls, they have consciousness. (...) they have to be free and we should not abuse them." (K. Erikçi). Even if you like the taste of meat, an animal is killed in the end. These animals are not creatures with low brain capacity like flies. They are also afraid; they also experience stress. They are thought to be "animals, not humans", but those creatures also have some fears, sorrows and troubles (Akçalı).

With regards to consumers, market acceptance is also an important factor. People may not accept cultured meat because of the 'yuck factor'. The use of language is important here. It can be shown in the quote from the CTO that: "if you say 'fake meat' then it is not considered as real meat although enzymes that are used in the production of many types of food are produced in laboratories" (E.Erikçi). The effect of the word choice and the press plays a crucial role in the acceptance of cultured meat technology. The CEO also indicated that since cultured meat comes from a laboratory, people consider it as artificial; however, it is not artificial and people need to understand the technology, the idea, the concept before buying it. His words can be helpful at explaining the concept of technology: "...cultured meat is not artificial. It is the same meat as we consume but the production methodology is

different." (K. Erikçi). He did an analogy from the tomatoes. When tomatoes come from greenhouses which are also controlled environments like culture mediums, people do not say that these tomatoes are artificial. The following quote shows the consumer acceptance of tomatoes that come from greenhouses: "Maybe there are some taste differences but nobody calls that this is an artificial tomato and I do not want to eat it" (K. Erikçi). He indicated that cultured meat is equivalent to greenhouse tomato in terms of production method.

Religion is another important aspect that needs to be considered in terms of the acceptance of cultured meat in society. In a symposium held in San Francisco, one of the representatives of the Jewish community spoke about the views of the Jewish people on cultured meat. According to him, as long as the animal does not go through the pain and the sources of the cells are not non-halal or non-kosher animals like pigs or snakes, etc. then this cultivated meat can be considered halal or kosher. The Muslim authority for giving the halal certificate in the American market was also present during the symposium. Considering the acceptance of authority, the CTO indicated that "I am confident that the religious authorities will allow the sale of this product. Then the people will follow it, so I do not think it is going to be a problem." (E. Erikçi). Economic factors also come into play in social acceptance. Presenting this kind of alternative protein for human consumption requires that it be affordable. It costs about two or three thousand dollars to produce one kilogram of meat today, according to current materials. Traditional meat continues to get more expensive. Hence, affordability is still observed to be the crucial element for people to accept clean meat. Although clean meat is known for being cruelty-free and environmentally friendly, most people will prefer it for its economic convenience (Akçalı). The categorized quote examples for social aspects can be found in Table 2 below.

General public	"**Anyone who is consuming meat would be interested**. This excludes

as stakeholders	the vegans only, but the rest of the humankind could be interested" (E.Erikçi)
Food producers as stakeholders	"We are approached by **meat companies, chicken companies** who are struggling to cope up with the feed prices or climate change or agriculture burdens or drought." (K. Erikçi)
Scientists as stakeholders	"When you consider conventional meat, they are always farmers or villagers or cowboys… But now things are changing rapidly, **scientists are the new farmers.**" (K. Erikçi)
Health concerns	"People are asking us if this is healthy or not and we tell them 'it is **at least as healthy as** today's conventional meat'. (...) production is a **closed loop production**, I mean, there is **no contamination, no bacterias, no food borne diseases.**" (K. Erikçi) "Once you do it in the laboratory, then you will not have those kinds of problems at all." (K. Erikçi)
Animal rights activists' concerns	"Some pioneers of veganism are against this technology because of some **concerns** like **this production method involves FBS and some other animal products.**" (E.Erikçi)
The yuck factor	"People may not want to eat it because of the **'yuck'** factor. (...) If you say **'fake meat'** then it is not considered as real meat although enzymes that are used in the production of many types of food are produced in laboratories." (E.Erikçi)
Religion concerns	"**The source is important and not giving pain is important**. Therefore I am confident that the religious authorities **will allow** the sale of this product. Then **the people will follow it**." (E.Erikçi)

Table 2

5.3. Sustainability

Sustainable ecosystems and environments are essential to the life of humans and different organisms. However, world demand for food has multiplied in recent years, promoted by rising wealth and sustained by the development of large, restricted animal feeding processes. These “assembly-line” food mills consume large amounts of energy, pollute water supplies, produce substantial greenhouse gas, and need ever-increasing quantities of wheat, soy, and other grains. This indicates that the traditional meat production systems are becoming less sustainable as the demand grows. The doubling of international food demand planned for the future 50 years poses immense challenges for the sustainability

of both the food industry and planetary ecosystems. This is the reason why an alternative such as cultured meat is required for a sustainable future.

Relative to traditional meat production, biftek.co's cultured meat is more sustainable. They use the "growth medium" method which is not producing the meat itself but utilizing the reproduction of cells -taken from cows- in a controlled environment. This means as long as the cheaply obtained microorganisms which trigger the reproduction of cells are preserved, there is no need for going back to the source animal to obtain more cells. The quote helps demonstrate that cultured meat technology is sustainable: "The technology itself is the enabler of sustainability." (K. Erikçi) To achieve mainstream qualities and commerciality, biftek.co researches methods to optimize the growth mediums economically. Cultured meat becoming mainstream would result in the diminishing of demand for "old-fashioned and unsustainable methodologies." (K. Erikçi).

As stated before, in the production of cultured meat, they use microorganisms to feed the stem cells. They keep these microorganisms in special freezers and reuse them when it is needed. This prevents them from going back to animals to produce more. The words of the CTO can explain their ultimate source of feeding the cells: "We don't need animals. We only need the micro-organisms." (E.Erikçi). Since their method of reobtaining microorganisms is sustainable, the technology itself can be considered sustainable. The quote effectively demonstrates that sustainability is a key in their technology: "Our technology is quite sustainable. And by contributing to the cultivated meat space, we are contributing to the sustainability of the world, since conventional meat production has no future but this technology does." (E. Erikçi).

Currently, the agriculture sector operates to be able to feed the animals that are raised to be consumed by traditional meat consumers. More than half of the agriculture production is to feed said animals. If husbandry ceases to exist when cultured meat becomes mainstream,

then that portion of the agricultural sector would switch their priorities to “feed” cells. The transition will not be swift and easy, the jobs will be converted into ones that will support the cultured meat industry. In this context, governments as a stakeholder would need to see those developments and push regulations accordingly. Investing in sectors that will be important in converting agricultural jobs into something that's going to be useful in the future is an important precaution that needs to be taken by the key policy-makers (E. Erikçi).

Since the future is looking more suitable for cultured meat rather than traditional meat, sustainability of this technology is important. In a future where the production of conventional meat is very expensive and the market is populated by cultivated meat producers, there could exist monopolies that occupy the meat production space by their patterns or by their capital power. However, this risk is not likely since local brands are stronger in their respective regions when it comes to the taste of the meat. For example, Cargill is one of the strongest meat producers in the world, however, they still would not be able to penetrate Middle-Eastern meat markets because Middle-Eastern flavor determines the demand in this case (E.Erikçi). The CTO indicates that today, the meat market occupies a great portion of the food sector that even a small portion of people's acceptance would be sufficient to sustain the cultured meat industry. Moreover, clean meat is projected to occupy more than half of meat demand by 2050, thus the sustainability of cultured meat is very realizable in the future. The CEO gives the example that people can use electricity that comes from burning coal or wind turbines. He stated that if they use clean energy coming from the sun or wind, they do not burn coal and if they do not burn coal then they do not "emit carbon dioxide or methane gases which warm the earth and change the climate" (K. Erikçi). This can be mirrored by the consumption of cultured meat against conventional meat. This quote is important to demonstrate that once people use clean and sustainable products, they quit using the ones that endanger the world. Thus, using cultured meat in the future decreases the use of

unsustainable methods. Some words of the CEO might be helpful in understanding the importance of preferring sustainable products: "If you choose something, it has some impacts, results. If you choose the right one, then the end product will be beneficial for you and for the globe and for humanity." (K. Erikçi). The categorized quote examples for sustainability can be found in Table 3 below.

Sustainable technology of cultured meat	"The technology itself is **the enabler for sustainability**. If people are consuming that kind of protein, which is called let's say clean protein, then **old-fashioned and unsustainable methodologies will diminish**." (K.Erikçi) "Our technology is quite sustainable. And by contributing to the cultivated meat space, **we are contributing to the sustainability of the world**, since conventional meat production has no future but this technology does." (E.Erikçi)
Sustainability by choice	"If you choose something, it has some impacts, results. If you choose the right one, then the end product will be beneficial for you and for the globe and for humanity." (K.Erikçi)

Table 3

6. Analysis and Conclusion

The examined field site, biftek.co, operates in light of Responsible Research and Innovation (RRI) practices. The cultured meat industry is a sector where responsible research and innovation become very significant due to the detrimental effects on the environment caused by the meat industry. Increasing population, limited land and water sources and husbandry becoming economically inefficient due to the increasing prices of fertilizers and feed urge the need to find an alternative way for meat production. Moreover, there are major social, economic and ethical concerns surrounding cultured meat technology. Social concerns include religion, yuck factor and economics while ethical and more conscientious concerns involve environmental issues, animal rights and sustainability. People who are concerned and involved with cultured meat technology, stakeholders, consist of nearly everyone including

animal-rights activists, environmentalists, meat consumers, people from the vegetarian and vegan communities, livestock farmers and more. The cultured meat technology of biftek.co shall be analyzed within the framework of Responsible Research and Innovation (RRI).

There are social and economic concerns revolving around cultured meat technology. For the case of cultured meat, religion, yuck factor, health concerns and economic aspects of the technology appear to be significant in terms of public acceptance of the technology. The workers of biftek.co attend conferences where different stakeholders come together and allow external values to meet. In the RRI framework, biftek.co follows the inclusion dimension by attending such conferences, considering these external views and broadening their values. The interviews conducted with workers of different positions in biftek.co suggest that the company follows the anticipation dimension of RRI and acknowledges such possible impacts of their technology on different social groups that form the stakeholders. The religious concerns involve the animal type in which the cell is obtained and whether the process of obtaining the cell is painful for the animal. The interview conducted with Dr. Erdem Erikçi indicated that biftek.co acknowledges such concerns as he mentions that “The source is important and not giving pain is important” about religious concerns (E. Erikçi). As a response, they came up with the solution to not use any non-halal/non-kosher animal cells. Similarly, another issue preventing public engagement is the yuck factor. Yuck factor is anticipated by biftek.co as the CTO talks about the yuck factor as: "People may not want to eat it because of the 'yuck' factor" (E. Erikçi). Yuck factor can be described as the apprehension and disgust of the public towards laboratory products and includes health concerns. Dr. Erikçi emphasized the importance of the use of language: “If you say ‘fake meat’ then it is not considered as real meat although enzymes that are used in the production of many types of food are produced in laboratories” (E. Erikçi). One of the solutions that biftek.co has is commercializing and introducing this technology as “clean meat” instead of

using terms such as “lab-grown meat” or “cultured meat”. The CEO Mr. Erikçi also mentioned the effect of the spread of misinformation preventing public engagement. As being familiar with the production process of cultured meat increases public acceptance of this technology (Bryant and Barnett 12), it is important that the public is familiar with the technology. Biftek.co is very vocal and informative about their process and research. They emphasize the importance of transparency and plan on welcoming such interests and informing the public better to break down the conflicts. Biftek.co emphasizes the importance of trust and transparency in the RRI framework for public engagement. In the later stages, similar to interviews they conduct, they can give conferences supported by the governmental authorities, the government of Turkey in the case of biftek.co, to increase public acceptance as their stance is also important as stakeholders of this technology. Biftek.co works in a solution-based method for the anticipated issues and conflicts about the innovation. They have a chance to observe the public perspective and answer questions during media interviews. Another social group that has concerns over cultured meat technology is the conventional meat producers and farmers. However, the CTO mentioned the increasing prices of husbandry materials and because it is not sustainable, the sector will be left in the future (E. Erikçi). The husbandry workers may work for growing animals for this technology with a change of the concept of husbandry. The economic aspect is another one of the major components of social concerns. The economic aspect of the technology is crucial for cultured meat to be marketable and accepted by the public. Cultured meat is in its early stages and is not economically accessible because the technology used is not economic yet. Although other technologies involved in cultured meat production are also evolving, biftek.co’s objective is to find an alternative serum to replace FBS which not only raises ethical issues but is also expensive. In this case, biftek.co aligns its value-sensitive design with public concerns and ethical values.

The social issues related to cultured meat include environmental concerns and animal rights. Social groups that share such concerns are environmentalists, animal-rights activists, many vegetarians, vegans and meat consumers and any other interested individuals. The increasing threat of climate change puts pressure on conventional meat production. The energy needed to source cultured meat can be obtained from environmentally-friendly energy sources. Even though at the current stage of cultured meat technology, improvements for environmental issues depend highly on the development of energy sources, it becomes a significant alternative to replace conventional meat production. Biftek.co is willing to adopt more environment-friendly practices as the CTO Erdem Erikçi states: “Renewable energy is becoming widespread and it is getting cheaper and cheaper. So carbon-free energy production is very important” (E.Erikçi). Biftek.co “places values in the center” not only for environmental issues but also for animal rights. Biftek.co follows the reflexivity and responsiveness dimensions of RRI. It is one of the presider companies to start implementing their innovative ideas about cultured meat in Turkey. They are not reluctant to public reaction and they aim to develop their innovation by giving importance to the responsiveness dimension. The concerns of animal rights encourage the development of alternative serums to replace FBS (Fetal Bovine Serum). As a solution, biftek.co uses microorganisms to develop serums and eliminates the need to kill the animal. This alternative technology allows vegan communities to be engaged in this technology as well since as CTO Erdem Erikçi mentions: “Some pioneers of veganism are against this technology because of some concerns like this production method involves FBS and some other animal products” (E. Erikçi). This innovative technology is still in the early development stages and this gives a lot of room for reflexivity. Considering the environmentally concerned young population and the many surveys done to understand the public acceptance, biftek.co limits the usage of FBS to merely a control group to compare the respective performances of the serums they develop.

Lastly, cultured meat technology becomes more crucial with increasing attention to sustainable methods. Conventional meat is not sustainable since it requires the extensive use of land and water sources as well as raising and slaughtering animals. Stem cell-based technology allows meat production to be done in a sustainable manner since it eliminates the need for land, water sources and does not rely on animal sources as the way traditional meat needs. The innovative technology serum that biftek.co develops will not require animal slaughter and the microorganisms can be used repeatedly. Biftek.co invests in special fridges to store the microorganisms. This method is developed to be more sustainable as a result of reflecting on the possible ethical issues involving sustainability that the future generations have and including them in the values of their technology. Even though the technology is in the early stages, biftek.co considers surveys that showcase public concerns. These scenario-based reports help reflect on the technology and in the RRI framework, including external perspectives in the developing stages of innovation. Biftek.co further considers possible bioreactor designs that can increase efficiency and are more sustainable. This allows the technology and the public to have common values and hence becomes more responsible. This technology requires energy sources. By using more environment-friendly and sustainable energy sources, the application of the technology becomes more sustainable as well. The interviews conducted with biftek.co indicate that they follow the reflexivity dimension of RRI by reflecting on the technology they develop by considering the values and placing them in the center of their design. Cultured meat offers sustainability by replacing unsustainable conventional meat production with the latest stem cell technologies. Biftek.co tries to include such concerns into their technology and further engage with the public by sharing common values before going into the market.

In the context of Turkey, Turkey became a part of the Paris Agreement on 10 November 2021. If cultured meat technology establishes itself as a significant food

technology stakeholder, this would help Turkey realize its climate action goals. The vegan and vegetarian communities in Turkey and those concerned about the environment are expected to be more open to the idea of cultured meat. In terms of religious concerns, the involvement of Turkish religious authorities could help remove the concerns of the public about whether cultivated meat is 'halal' or not. Cultured meat can then be expected to enter mainstream markets and be consumed without hesitation. In addition, with the standardization of cultured meat, its price as a food product, in the long run, would be expected to decrease. Competitive prices would encourage the general public, including meat-lovers, to accept the consumption of cultured meat.

In conclusion, biftek.co and the cultured meat industry's efforts can potentially have a major impact on global sustainability. Since the demand for meat increases exponentially, it must be met in a way to prevent and cope with world hunger. In this regard, cultured meat shows promise as an alternative meat source. It can provide nutrition and assure a steady food production on a planet strained for land and water resources in addition to natural disasters caused by climate change. It could potentially decrease malnourishment issues, diminish food-borne infections, and prevent contamination. Moreover, it would help decrease the present-day inefficient and unsustainable conventional meat production since other than animal cruelty the traditional meat sector directly harms the environment and contributes to climate change because of its large production volume, waste and greenhouse gas emission rates. With responsible research and innovation, the cultured meat industry is set out to replace the status quo and become a more sustainable meat alternative first before entering the main market as an alternative meat source for people and meeting their expectations for how they view meat in terms of flavors and textures. The technology is in its early stages which leaves room for responsible practices to be further incorporated into its development as it grows. In this way, problems stemming from conventional meat production would be

surpassed, animal cruelty would be minimized, and it would not be inaccurate to claim that a more sustainable future could potentially be realized.

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8. Appendix: Interview Transcripts

8.1. Interview with CEO Kerem Erikçi

Interviewer: What are the general developments in the cultured meat industry?

Interviewee: So, cultured meat industry is just reshaping, actually, not reshaping but forming let's say. Cultured meat is a new concept, as you know. I think it's like 2013. A professor called Mark Post from the Netherlands tried to do the first sample of cultured meat by the finance of Google founders, Sergey Brin. So, the first hamburger was like $300,000 per piece and they showed that by getting a single stem cell from a cow is enough to produce meat abundantly; however, it is very expensive. As I told you, a burger is more than $300,000. Nowadays, it is less than $3,000. So, there is a huge reduction in the cost. Still it is not commercial. So, nowadays, people are looking for new methodologies to produce it but commercially it is not viable. So, if people can find out new methodologies like bioreactors, new growth mediums, -----? folding technologies, we will be able to consume it in maybe the next five years. So, it is still in research and development phase. There are some ----? factories but these are for like PR stuff. But I believe, in five to ten years, this will be reality for all the public.

Interviewer: Which stakeholders are relevant for this technology?

Interviewee: Actually, the end users are you and me, the general public. But before coming to that, stakeholder, most of the guys in industry are genetics or molecular engineers, scientists. So, when you consider conventional meat, they are always farmers or villagers or cowboys… But now things are changing rapidly, scientists are the new farmers. So, also the

conventional ecosystem has an interest in cultured meat, for instance, we are approached by meat companies, chicken companies who are struggling to cope up with the feed prices or climate change or agriculture burdens or drought. So, they are not very happy to raise cows, cattle, chickens or any kind of meat source because of financial issues and for sustainability issues. For instance in Germany, people are thinking to put on tax on the meat. If you consume meat, it is relatively cheap over there, but government is thinking to make meat pricey. Because the label on the price tag does not reflect the real burden on------? So, in order to produce one kilogram of meat, you have to consume 15 tons of water, lots of land, it releases carbon dioxide and methane gases and also it uses antibiotics, it is not very healthy for us. So, stakeholders are scientists, ------? and general public.

Interviewer: So, what about vegetarians and vegans? Are they on the supporter side?

Interviewee: Not ------? of those guys supports what we are doing. There are two kinds of vegetarians or vegans I believe. One does not like meat at all, the concept, taste, smell, look… they do not like it; so, they chose to be vegetarian or vegan. Some are more interested in animal welfare, climate issues, the resource consumption, sustainability; so, they do not like to consume meat because meat is one of the suspects of climate change and agricultural issues. If you are a vegan that does not like this meat production, for sure, you support us but if you do not like the meat concept at all, they are indifferent if it is clean meat, cultured meat or conventional meat coming from classical methodologies, they are indifferent. But in general, vegan community and vegetarian community support clean meat movement.

Interviewer: What are the risks?

Interviewee: The risk is mainly psychological or sociological. People have to understand the technology, the idea, the concept before they purchase it. People are thinking that since it is in laboratory, it is artificial; however, cultured meat is not artificial. It is the same meat as we consume but the production methodology is different. Let me do an analogy. You can buy a tomato from the grocery store and when you ask the people over there what is the source of this tomato, they can tell them that it is coming from agriculture field or from greenhouse. If it comes from greenhouse, you do not say "Hey, this tomato is artificial tomato"; it is tomato but coming from greenhouse. In greenhouse, you take the soil by use of different -----? or -----? So it is a controlled environment, a closed environment but you produce tomato. So, those two tomatoes are same. Maybe there are some taste difference but nobody calls this is artificial tomato and I do not want to eat it. It is going to be something like that and people should be aware of the fact that meat is one of the biggest climate changers.

Interviewer: What adjustments have been made or will be made to technology in response to users or stakeholders interests or risk concerns?

Interviewee: Actually, there will be some early adapters and then followers and then it will reach to the momentum. The early adapters will be vegans and vegetarians, for sure. They are going to try it and then they will see the benefit of cultured meat not only in climate issues but also in price issues. Because, nowadays, Turkey is experiencing drought. Since there is hemi drought in Anatolia, cattle feeders cannot buy or reserve feed materials like wheat or barley. So, that means they have to pay a lot to feed their cows during the winter time. It will increase the prices, for sure. If they cannot feed the large stock, then most probably they are going to send their inventory to slaughterhouses. So this means, in the summer term, there will be a lack of meat resources. If there is low supply, prices will rise again. So, this cycle

will follow each other and at the end of the day normal meat or conventional meat will be very pricey when compared to conventional meat although this is a vice versa nowadays. But if you have a closed area and if you do not require any kind of water, land, antibiotics and grazing animals, this kind of production methodology will be very cheap compared to the conventional. So, people can consume it very easily and the general public will adapt it after early adapters. And for sure there are some health concerns. People are asking us if this is healthy or not and we tell them “it is at least as healthy as today's conventional meat” because -----? production is a closed loop production, I mean, there is no contamination, no bacterias, no food borne diseases. Because closed cycle production does not allow any kind of contamination. If there is contamination, production stops, cells cannot divide each other. There is almost no antibiotic consumption. 80% of the antibiotics globally are consumed by animals. It is a shocking number. We do not consume a lot in terms of antibiotics, but we use antibiotics on animals for them to stay healthy. At the end of the day, you consume these antibiotics while you are eating meat. This is a huge problem and people will see it and, lastly, people are exploiting animals a lot. You know this covid virus is coming from the exploitation of animals in China. There is the bat market, all kinds of animals are slaughtered there and this creates lots of viruses that we do not know may harm humans. So, covid is the simple stuff. SARS or swine flu or bird flu, mad cow diseases… all of these things are coming from animals to people. That’s why today you are wearing your masks because we are abusing animals. So, once you do it in the laboratory, then you will not have those kinds of problems at all. For animals, it is better to be free, right? We see animals as machines of milk or meat but they are not. They have soul, they have cautiousness. We like dogs but we eat cows or we eat chickens. It is hypocrisy, I believe. For instance, in China people can eat dogs as well or any kind of meat is okay for them but chickens or cows or sheep or other

kinds of animals are not here on earth for us to eat them, they have to be free and we should not abuse them.

Interviewer: Thank you for your answer. So the other question is, could you elaborate on the ways biftek addresses sustainability as a company?

Interviewee: Actually our product is a sustainable product. If you use our product, you don't use the others. You don't need to use the others. The others are unsustainable. It is something like that. You can use electricity coming from the wind or by burning coal. If you use clean energy coming from the sun or wind, you don't burn coal. If you don't burn coal then you don't emit carbon dioxide or methane gases which warm the earth and change the climate. So it is your decision. If you choose something, it has some impacts, results. If you choose the right one, then the end product will be beneficial for you and for the globe and for humanity. So our technology is an enabler for cleaning to be more affordable. Let me introduce what we are doing now. We are not producing the meat itself but there is a concept called 'growth medium'. Once you get the cell from the cow, you place it into the growth medium and by use of this growth medium, the cell can divide and reproduce itself. So this growth medium is a very special solution and we are trying to optimize and produce this medium as cheaply as possible. Nowadays those growth mediums are insanely expensive. That's why one kilogram of clean meat is more than a thousand dollars. If we can lower this growth medium price, then this can be mainstream or commercial. So the technology itself is the enabler for sustainability. If people are consuming that kind of protein, which is called let's say clean protein, then old-fashioned and unsustainable methodologies will diminish.

Interviewer: Thank you so much for your answer. So, this is going to be our last question. How do you see the future of cultured meat in Turkey and globally?

Interviewee: Actually, our customers are not in Turkey right now, they are from everywhere. People are asking for our ----? from Singapore, Germany, UK, Netherlands, China... So this is a global movement and since it is in the early stages, people are cooperating heavily. Turkey doesn't have the knowledge right now. There are some discussions, however, those discussions are not based on facts or information or truth. There are some rumors, gossips. So gossips are amplified somehow and people can not obtain the truth. It is like the vaccination. If you get vaccinated, then there will be an IC, a chip in your blood and the big guys can control you, right? So those kinds of stuff have buyers in the public. However, once there are the facts and truth, there won't be any transition stage. People will learn the basics of science and there will be some regulations for sure from governments. There will be lots of tests, if this is healthy or not. If you are producing a biscuit, and sell it in a bakery some government officials come and check you right? If the flour is okay, the sugar is okay and everything is in its place, then they approve you. It is going to be the same. This will be a source of protein. People call it alternative protein. Maybe you don't need the meat but you need the protein. So eating meat is a cultural stuff. It has some religious issues in the production. These religious things are subject to many people globally. Not only in Turkey but for instance in Jewish community, this is an issue. They call it Kosher. It is very strict. As strict as Muslim practices. So they are all thinking about it. At the end of the day, if rules are okay, I see it is okay because I saw lots of positive speeches from those religious people then it will be mainstream. It is like tomatoes from a greenhouse, tomatoes from the field. It is going to be the same stuff.

Interviewer: Okay, thank you very much for conducting this interview with us.

8.2. Interview with CTO Erdem Erikçi

Interviewer: What are the general developments in the cultured meat industry?

Interviewee: Cultured meat sector should be able to represent the body of an animal in a laboratory. Mimicking whatever is happening in the body of a cow should also be happening in a laboratory environment. Anything you develop The structure of tissues ------? The cells that should be grown should be in an environment that feeds the cells. This is called cell culture medium. It contains vitamins, saccharides, sometimes proteins, amino acids, antioxidants so and so, for it has lots of components. There are 56 components from what I remember. Plus, you need to add growth factors to be able to keep the cells alive and push them forward to proliferate. In a regular cell culture laboratory, FBS (fetal bovine serum) is used to be able to keep the cells alive and proliferate them. it contains the proteins that give them the signal to proliferate. However, it is very expensive and its origin is animal. As the name implies, it is Fetal Bovine Serum so it is the blood serum of the fetal bovine. You have to kill the fetal bovine to be able to obtain it. And, it is completely contradictory to the philosophy of cultured meat. Therefore, it must be replaced. So, another developmental, let's say, side of this whole project is to make growth more feasible -----? it is the blood serum of a fetal bovine. Therefore another culture medium should be discovered. Although I'm saying discovered, a little modifications on the current bioreactor designs should be sufficient. This is what is being done right now. People are designing it in such a way that this production of muscle stem cells would be much efficient and cheaper. So, in summary, bioreactors. Any technology that is needed to produce the meat in 3D structure and the growth medium the cells will be fed in. So those are the three areas that require some investigation.

Interviewer: On to the next question. Which stakeholders are relevant to this technology? Who are the ones directly or indirectly affected by this technology?

Interviewee: The simplest answer to this question is: anyone who is interested. Who could be interested? Food producers indeed. Because, cultured meat is considered a next generation food. Meat is being consumed by all animals almost. I mean carnivores and also omnivores. Anyone who is consuming meat would be interested. This excludes the vegans only, but the rest of humankind could be interested, right? But I am sure you are asking more specific stakeholders. For example, in terms of the sector; food sector as I have said, any sector relevant to agriculture, pharmaceutical companies. Food is a strategic product. Who controls the food can control the world, therefore food is a matter of national security thus governments are stakeholders. People will demand the food, particularly the meat. If you cannot provide it then you have no chance to sustain your government. Research laboratories, it is a matter of research and development. Academia must be involved in this process. And the investors, some investors are investing in this business just for the sake of the animals, some are investing to be able to share the risks they have. What I mean is, big food companies need to invest in developing technologies. Because in the near future -all the projections are saying- the meat production must change and if they continue to do the production as usual they can't sustain their business. It is either going to be very expensive or they need to stop. I have some friends who were in the husbandry sector. They just left the sector. They don't feed any animals because they say the income cannot compensate the expenses because of increasing prices of fertilizers, feed, animal care. Even today you can see that husbandry cannot be sustained with the methods of business as usual. So they are also the stakeholders.

Interviewer: What about animal rights activists and restaurants in general?

Interviewee: There is a new trend among the restaurants. There are some restaurants that used to sell animal products. They stopped and started only selling alternatives. Therefore the restaurants are going to be sparing some parts of their menus. In the ----? future, there are going to be some meals made out of cultured meat. In Singapore, there is a restaurant called 1880. They are selling chicken nuggets that are made of plants plus cultured meats. So it is considered as the first cultured meat product and it is on sale in Singapore because the regulatory environment allows it. I guess it is going to be followed by the USA probably next year. And then Europe will follow and then it will go down to Africa and the Middle East.

Animal rights activists can be divided into two: Ones who are against this technology and the ones who are in favor of this. There is an institute called Good Food Institute in USA which is a non-profit organization that supports alternative protein. The founder of that institute is a vegan and most of their workers as well. But some pioneers of veganism are against this technology because of some concerns like this production method involves FBS and some other animal products. Their opinions are worth consideration but actually cultivated meat will not be on market before solving the FBS problem. As the technology develops, as those problems are solved, I am sure that they will be convinced.

Interviewer: What are the risks in general?

Interviewee: So one of the risks is the failure of the technology. Maybe the technology will never be mature enough to produce large quantities. So the upscaling may fail but it is not

very likely because there are already some prototypes that prove this is going to be feasible. We can divide technology-relevant risk into several parts. Maybe FBS cannot be replaced or the 3D structure can never be produced therefore only minced meat could be produced but not a steak or chicken wings. Another risk could be bioreactors being very very expensive which would prevent the production from being feasible. I don't think it is likely though.

There might be some monopolies. Imagine a world where the production of conventional meat is very expensive and the market is populated by cultivated meat producers. They occupied this space by their patterns or by their capital power. They could be controlling the meat but again I don't think it's very likely. What's happening today could happen in the future; there are big meat and food producers that are strong but on the other hand there would be also local brands. Cargill is one of the biggest in the world but we have Pınar, we have Maret in Turkey; so the local taste would be the determining factor here. Cargill can never penetrate into Turkish market or Middle Eastern market because the taste that we are used to is much different than the taste that Europeans like. It is not very likely as a risk but still I wanted to mention it.

Another thing is producing meat through cultivation may not be realized. For example, CO2 emissions is another problem. The cleanliness of cultivated meat is dependent on other technologies. Cultivated meat technology will not solve everything along the way, so the technologies will go in parallel. Failure of one sector would be the reason for the failure of the other but again I don't think it is likely. Renewable energy is becoming widespread and it is getting cheaper and cheaper. So carbon-free energy production is very important.

We shouldn't forget the market acceptance. People may not want to eat it because of the "yuck" factor. The press and the language that they use are very important here. If you say "fake meat" then it is not considered as real meat although enzymes that are used in the production of many type of food are produced in laboratories. So, the people may not be fond of buying cultivated meat. The meat market is so big that even small portion of people's acceptance would be sufficient to sustain the sector. Some reports say that more than half of the market will be occupied by clean meat by 2050. Imagine, in thirty years one out of two meats in the market will be either plant or cell-based. It is hard to imagine today because we don't have many options on the market shelves today as alternative protein sources but by 2050 it's going to be such a norm.

Interviewer: What about additional risks that are religious issues perhaps or when cultured meat eventually replaces conventional meat what are going to be the costs to traditional agriculture sector?

Interviewee: There was a symposium in San Francisco and one of the representatives of Jewish people came to give a talk about the opinions of jews on cultivated meat. What he said was -and besides the Muslim authority for giving the halal certificate on American market was also there- as long as the pain is not given to the animal and the source of that cell is not from un-halal or non-kosher animals like pigs or snakes, cultivated meat can be halal or kosher. So the source is important and not giving pain is important. Therefore I am confident that the religious authorities will allow the sale of this product. Then the people will follow it, so I do not think it is going to be a problem. What was the next question?

Interviewer: Costs to the traditional agriculture sector. What are going to be the changes?

Interviewee: So the agriculture sector actually operates to be able to feed the animals today. More than half of the production is to feed the animals that we eat. If there is no husbandry anymore, then that portion of the agricultural sector would make production to feed cells. There will be some transition but it won't end. Agriculture is the beginning of civilization and civilization will continue with agriculture. The transition will be of course not as easy as one can imagine, the jobs will be converted into something else. Governments as a stakeholder should see those developments and take precautions accordingly. They must be actually investing in sectors that will be important in converting those jobs into something that's going to be useful in the future. Planning is the key here.

Interviewer: What adjustments have been made or will be made to technology in response to users' or stakeholders' interests or risk concerns?

Interviewee: So, we have realized a problem in the sector. And this problem is FBS alternatives. We have to feed the cells in an alternative way and then we decide to concentrate on it. Then we convinced investors that this is a real problem. And they understood what the problem is and thought it was worth investing in because it has a future. We did not change our idea much. We already knew this was something that needs to be solved and that it will have a market. We are not being changed by the investors, we are being followed by them.

Interviewer: Could you elaborate on the ways biftek.co addresses sustainability through technological designs and/or organizational practices?

Interviewee: We are trying to feed the cells using microorganisms and producing those microorganisms is very cheap and the method is very straightforward. Although we obtain those microorganisms from animals, we do not need to go back to the animals to produce further. We can keep them in -80 ----? freezers and we need them we just thaw them and then you know, proliferate those micro-organisms and then obtain their metabolites. The way we sustain our methods is done by this way. So, we don't need animals. We only need the micro-organisms. So as long as you go along with them, they are happy to secrete those cells - to secrete those metabloids. So in that sense, our organization is quite sustainable, I mean our technology is quite sustainable. And by contributing to the cultivated meat space, we are contributing to the sustainability of the world, since conventional meat production has no future but this technology does.

Interviewer: What is the future of cultured meat in Turkey and in the World?

Interviewee: In my opinion, the future will come much sooner than we anticipate so I don't know if you have ordered plant-based whopper from Burger King recently. Did you? Alright, I would recommend you to do it. It was the beginning of this year that pilot sale was like announced in some of the Burger King restaurants. It was in a couple of restaurants in Ankara, the plant-based whopper was on sale. But today, since one month ago, you can order it online and it is available in all the Burger King restaurants. And it is plant-based so there is no animal product in this manner. So if you consider the predictions of two years ago, those plant-based products would be worldwide ----? and you can even go and buy a plant-based whopper in Kizilay or Bilkent. A Burger King restaurant in the middle of nowhere is even selling it. Therefore, in my opinion, cultivated meat will be widespread all around the world much sooner than we anticipate. That is why I see the future as bright. Although there are a

lot of conspiracy theories, like ‘the end of the world has come’, ‘winter is coming’, blah blah. If we can solve this problem, the biggest part of this climate change story would come to an end since like 24% of greenhouse gas emissions is due to agriculture and 15% of it is due to husbandry. So solving this problem will be possible. If you may spare the agricultural land which is spared to feed the animals today to something else - if you leave that extra part alone, extra area alone, nature can regenerate itself in a very fast manner. Nature wants to live if you remove the pressure people apply on nature then nature can regenerate itself in a couple of years. It happens. It is always what can be observed in nature. That is why I see the future as promising. And Turkey you said? In my opinion, Turkey is going to be one of the pioneering countries in the Middle East and Asia. Right now, we are alone, once this technology is proven to be feasible, there will be hundreds of countries who will make investments in this business and who are producing the products and selling those products. And the people of Turkey, a big portion of the people of Turkey, are mostly early adapters. We like to try new technology, new tastes, there are going to be lots of people who will show resistance to this novel food but there will be lots of people who will be early adapters.

8.3. Interview with CSO Can Akçalı

Interviewer: As the first question, we would like to hear from you about the developments in the artificial meat industry.

Interviewee: Now, first of all, we don't actually call it artificial meat. So, when we say this artificial meat as a noun, it is thought of as something plastic, false, unreal. Here, it is called "lab-grown meat" or "cultivated meat", which we mostly use. Actually, the starting point of this is that it is not a new phenomenon. Due to the rapid increase in the population and some energy and climate problems, people have gone for an alternative protein source. There is a

wide variety of alternative proteins. One is called "plant-based meat". What we call “meat” is a muscle cell. However, in this case, it is presented by growing certain proteins and molecules that give meat its nutritional value and taste, by growing it in plant cells and developing it in something called "scaffold" - giving the meat shape - correcting its taste and color. This is something that fits the concept of artificial meat. It has been on the market for years now. This derivative with a four to five percent market share in America. You can find them in markets abroad. If you haven't tried it, it will be a bit of advertising, but Burger King has something called a "plant burger". It's not actually a meat, it's a vegetable-based hamburger. When you taste it, you don't notice the difference anyway.

The second thing, the so-called "cell based meat" - which is what we're dealing with in biftek.co - is derived from cells. In other words, when we say cellular origin, we mean this, in fact, an event that occurs in normal development is mimicked in terms of muscle. Normally, muscle cells consist of cells that we call muscle stem cells. Whenever our muscles go into atrophy or have any problems, these cells become adult muscle cells. The starting point of what we call "cell based meat" or "lab-grown meat" is if you can isolate the stem cell with a biopsy here; If you can differentiate these muscle stem cells into muscle stem cells, this phenomenon is called "differentiation". Daughter cells are formed from the mother cell. This is how the "fetus" then develops.

There are other alternative protein sources as well. One of them is the use of insects. What has been used in the Far East for years is actually used in Turkey now. Especially the proteins obtained from grasshoppers can be put into foods because of their high nutritional value, and there is no problem with that. So, in answer to your question, this need actually stems from an

alternative protein source research against increasing population and decreasing world resources.

Interviewer: As a second question, can you define groups or people related to this technology?

Interviewee: Now, what I just told you is actually a known thing. Producing muscle cells from muscle stem cells is not difficult, but the problem here is that the material used during the process is very expensive. If this technology is to be presented for human consumption, if people are going to consume it as an alternative protein, it must be affordable. It costs about two or three thousand dollars to produce one kilogram of meat today, according to current materials. Therefore, it cannot be expected to use a product in this price range. Another business questions of this technology is "How can this price be lowered?" or “how to make technology more affordable?”. That's what we're trying to do at biftek.co. We are trying to continue with an approach that can replace those very expensive growth factors -a substance called "fetal bovine serum" obtained from the embryo- which is much cheaper and does not use animals. Fetal bovine serum is taking the baby inside the pregnant cow in the mother's womb and drawing all its blood and centrifuging that blood to get a serum. Inside this serum are all the factors needed for the growth of that embryo. But when you look at it practically, you don't need to develop bones or horns, skin and digestive system to make meat in the laboratory. Fetal bovine serum is expensive because it contains all the components. Thus, bringing biotechnological or innovative solutions is also an important point for companies. The bioreactors that will produce these cells are also a separate business area. While this technology comes within itself, it activates not only meat production, but also many other systems or business areas around it.

Interviewer: As a continuation of this question, can you explain the relevance of, for example, animal rights activists or, more socially, the public?

Interviewee: Think for yourself as the public. If you do not have a personal sadistic trait, you would not want to harm an animal. Even if you like the taste of meat, an animal is killed in the end. These animals are not creatures with low brain capacity like flies. They are also afraid; they also experience stress. They are thought to be "animals, not humans", but those creatures also have some fears, sorrows and troubles. Especially with meat produced in the laboratory; It is an alternative for the vegetarian part because it is made without killing animals, or for people who simply refrain from killing these animals and therefore do not eat meat. There's the word lamb chops. When you think of lamb chops, it's mouth-watering, but when you think of the lamb before it dies, it's hard to get the same taste. This is not always the case for vegans, because vegans are also against taking a biopsy. But a solution for vegetarians and an important solution for animal welfare. Hundreds of millions of animals are killed every day. Of course, human nutrition is important, but as the human population increases, the number of animals killed increases. Let's eat the meat of the animal, but without harming the animal. This is actually the starting point of "cultivated meat".

Interviewer: As the third question, what are the risks related to this technology in terms of technical designs or social issues?

Interviewee: The biggest risk related to this technology is the public's acceptance of this technology and the biggest obstacle to this is the economic aspect. Traditional meat is getting

more expensive and will continue to be so in the future as well. On the other hand, the clean meat production technology we produce tries to offer affordability. Technology evolves in every era. Similar to how we can conduct this meeting through our computers, the biotechnology of clean meat production is also improving and becoming more affordable. So the public that may utilize this technology will be your grandchildren where traditional meat will be expensive as well. FAO foresees that 10% percent of the conventional meat consumption will be clean meat in 2030. There is of course the 90% percent but to increase the 10% percent, the technology must be affordable and then the public reception would increase. However, we anticipate that this problem will decrease rapidly in 5 or 10 years with further investment into this technology. Some groups of people may resist with religious concerns however when affordability is still observed to be the crucial element for people to accept clean meat. Although clean meat is known for being cruelty-free and environmentally friendly, most people will prefer it for its economic convenience.

Interviewer: You have mentioned some risks and stakeholders related to this technology. What adjustments have been made or are planned to be made in the future to the technology in response to these risk concerns?

Interviewee: I can say that there has not been a major change. First, you need to obtain the root cell and then, produce the cell and transform it into a muscle cell. The idea is the same. It is the same from the beginning. In Holland in 2013, one kilogram of hamburgers would cost 330 thousand dollars. That is an odd number. With the developing technology, the price was managed to be reduced to 2-3 thousand dollars in 7 to 8 years. Therefore the science behind remained the same. The important thing is to reduce the cost. This was mostly achieved by finding cheaper tools that are used in production. Similar to how we left telegram technology

to more advanced technologies as they received investment, clean meat biotechnology is also getting more affordable with finding more affordable tools with investments.

Interviewer: This year, our topic is sustainability and we know that sustainability is also important for biftek. Could you elaborate on the ways biftek addresses sustainability with technological designs or in terms of organizational practices?

Interviewee: The aim of biftek to reach sustainability is by offering these more affordable sustainable methods to the market. Instead of the serum obtained from the calf, we use microorganisms. We base our technology on microorganisms, bacteria. Therefore the sustainability of these is a lot more possible. After the bacteria is used, it is preserved in special fridges, when there is another need to use bacteria, the same bacteria is ready to be used again. Therefore there is no need for other humans or living beings. Other than offering affordability, the investors are interested in our technology as our methods also offer sustainability.

Interviewer: As our last question, what do you think about the future of cultured meat in Turkey and in the World?

Interviewee: I can say that it is inevitable. I would like to specify that we are talking about the times of your grandchildren, 30-40 years from now, it will be received by the public. Similar to how other technologies have been accepted by the majority of the population, clean meat technology will also be accepted by the majority. It is inescapable. If the population keeps rising like this, in countries like Southeast Asia, those people will also have a need for consuming meat. Poor or not, that is a need. It is not only the concern of such

countries but it should be thought by every country as such a big consumption would affect every country. Globally, such effects will be seen in around 10 to 20 years. Then, clean meat will become inevitable. The aim is to be as quick as possible to make this technology more common and affordable.

9. Credits

Aysel Başak Bula conducted the CEO interview and transcribed half of it. She attended the trip to biftek.co laboratories and she has taken pictures. In the term project, she finalized the findings part and constructed the charts for findings. She found alternative and academic sources for the term project.

Efecan Şentürk conducted the CEO interview and took part in transcribing it. He attended our trip to biftek.co laboratories and wrote the background research part with Sehar Irfan Mangi. He also found alternative and academic sources for the term project.

Ömer Durukan Kılıç conducted the CTO and CSO interviews. He found alternative and academic sources for the term project. He wrote the sustainability part of findings, method, introduction, a portion of analysis and conclusion and references sections in the term project. He also edited the text in a minor way and attended the trip to biftek.co laboratories.

Sehar Irfan Mangi set up and conducted the CEO and CTO interviews. She wrote the background research part with Efecan Şentürk and undertook the main editing part of the term project. She found alternative and academic sources for the term project. She attended our trip to biftek.co laboratories and also took the lead role in the coordination of our research group.

Zeynep Şahin conducted the CSO interview. She transcribed half of the CSO interview and half of the CEO interview. She attended the trip to biftek.co laboratories. She found alternative and academic sources for the term project. In the term project, she wrote the technical aspects of findings, theory part and a portion of analysis and conclusion. She also edited the text and citations.