IN VITRO MEAT INDUSTRY: LEGAL ANALYSIS OF MANUFACTURE AND CONSUMPTION IN FIQIH PERSPECTIVE

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Abstract

The development of science and technology has had a major impact on all industries, especially the livestock industry . The development of processed meat from animal cells without going through cultivation is part of the convenience that is influenced by this science. Processed meat is termed in vitro. However, this has become a polemic regarding the halal status of consuming meat produced from the processing of animal cells. Because the in vitro meat industry is still relatively new. The research aims to provide answers to the above problems based on the views of fiqh, so that it can be used as a reference for many people about in vitro meat. The method in this study uses library research or *library research*. While the analysis uses content analysis. As for the research results from this article, it is legal to make in vitro meat or artificial meat from animal cells permissible. Because there is no argument against this action, apart from that this industry is also part of the development of science. While the law consumes it is also lawful. This halalness must be based on animal cells that will be used as the development of meat originating from animals that are also halal to eat.

Introduction

Advances in science and technology always provide answers to every problem faced by the world and mankind. It should be noted that the current world population is 7.3 billion and is expected to continue to increase to 9 billion in 2050. The Food Agriculture Organization (FAO), an organization engaged in food and agriculture, estimates that by 2050 the demand for food will increase by 70%. This is due to the increase in the human population. On the other hand, natural resources continue to decrease, such as limited land because it is used as a residential area. Agricultural land and livestock will become increasingly difficult (Chriki & Hocquette, 2020) . The impact of consumption needs of society is not met properly. To overcome this problem, scientists have developed a new industry in the field of animal husbandry by making meat without having to go through the cattle farming process which takes up a lot of land.

Production of meat through brooding processes in the laboratory or known as in vitro meat, artificial meat, cultured meat and others is considered as a solution to the demand for meat which has been produced through conventional farming. In 2013 it is estimated that around 14% of greenhouse gasses (GHG) emissions are produced by livestock (Defendi-Cho & Gould, 2023). This in vitro meat has the potential to provide environmental and social benefits because the process is environmentally friendly and also does not need high costs (Tuomisto & Mattos, 2011), when compared to meat produced conventionally. This cell culture usually requires fetal bevino serum (FBS) as a medium for increasing animal cells (Defendi-Cho & Gould, 2023) .

Based on current commercial prices, the cost of culture-grade FBS is estimated at approximately $1.20 per mL and other media components at $0.04 per mL; thus, for a complete growth medium containing 10% FBS, a large portion of the total cost is attributed to FBS, roughly threefold. Removing animal sera from culture media will not only reduce costs, but will also avoid the problem of contamination of pathogens (eg, viruses) that may be present in animal sera (Barone et al., 2020). The estimated cost of in vitro meat above if the industry is used with FBS media. So it is clear that the in vitro meat industry is very environmentally friendly and also low cost.

The in vitro meat industry has actually been developed for a long time. At first it started with the ideas of two Western scholars, namely Fredick Edwin Smith and Winston Churchill in the 1930s (Hamdan et al., 2019). They got the idea to develop in vitro meat because they were inspired by a scientist named Alexis Carrel who had succeeded in ensuring that chicken heart cells could live ex vivo for a long time. This effort was carried out well and got almost perfect results (Bhat et al., 2015). Then in 1999, Willem van Elen from the Netherlands became the first scientist to obtain permission in various countries including the United States to develop the concept of in vitro meat (Schneider, 2012) .

Three years later, a group of scientists led by Benjaminson managed to culture goldfish muscle tissue. The technique they use is almost the same as Alexix Carrel's (Hamdan et al., 2019) . However, the scientist who first developed cultured meat in the form of beef burgers was Dr. Mark Post. The meat was tested and cooked by two judges at Riverside Studio in 2013. As a result they are very satisfied with the shape,

taste and smell resulting from the culture and they state that the taste is exactly the same as the meat produced through conventional farming. (Hamdan et al., 2019).

In vitro meat, as explained above, is very important to support human flesh needs. Of course, the in vitro meat industry provides great benefits because it helps reduce greenhouse gas (GHG) emissions which are also contributed by the livestock industry. However, the problem is related to Muslims, where Muslims must eat everything that is halal and good for their health. Legal studies on in vitro meat have not been carried out by many scholars working in this field. There is some literature written about in vitro meat and its relation to jurisprudence. There are types and forms of cluster division.

In the type cluster section as written by (Hamdan et al., 2019) " The Use of Stem Cells in Cultured Meat: Analysis According to Islamic Law" and (Mohammad Naqib & Mohd Anuar, 2016) "Cultured Meat in Islamic Perspective: An Analysis to the Use of ESCs as Source of Stem Cell" states that meat developed from cells of the ESC type in fiqh is unlawful even if it comes from animal cells which may be eaten. In the form cluster written by (Farhana & Jasmi, 2022), namely "Production of Cultured Meat and Views in Islam" the authors conclude that cultured meat or also known as in vitro meat is not halal in general both in the form of ESCs and ASCs. The author argues that the meat is equated with blood or fetus which is unclean to eat. In this case, the author will examine the basic laws of the cells to be reproduced using the analysis of several schools of jurisprudence, such as Imam Hanafi, Maliki, Shafi'i, Hanbali and also contemporary jurisprudence related to the author's discussion.

This paper aims to find out how the law of making meat produced through cell reproduction and how the law of eating meat relates to Muslims, this study is reviewed in a comprehensive manner on well-known and contemporary fiqh. So that it can be a reference in responding to the challenges of the new in vitro meat industry.

Methodology

research method was carried out using library research , namely research conducted using existing literature, in the form of books, journal articles, notes, documents, previous research reports and reports from internet websites . The data collection technique in this study was that the researcher read literature related to the meat

industry in vitro and analysis of the law of jurisprudence, then the researchers examined and put it theoretically into writing. While the data analysis technique uses content analysis. In this process the researcher sorts out content related to fiqh analysis regarding in vitro meat law, and compares and analyzes existing data to be discussed and studied in depth so as to produce critical conclusions according to the data that has been collected.

Results and Discussion

Cell Selection as a In Vitro Meat Production Material

In vitro meat can be produced from cell sources grown from plants, such as decularized spinach leaves and soy protein (Jaques et al., 2021) or known as vegetable meat and can also be from animal cells such as cows, goats and others. others (Singh et al., 2023) . However, in this discussion, the authors will only focus on discussing in vitro meat produced from cultured animal cells. The stem cells used are divided into two; namely Embryonic Stem Cells (ESCs) and Adult Stem Cells (ASCs/Non-Embryonic Stem Cells) (Hamdan et al., 2019) .

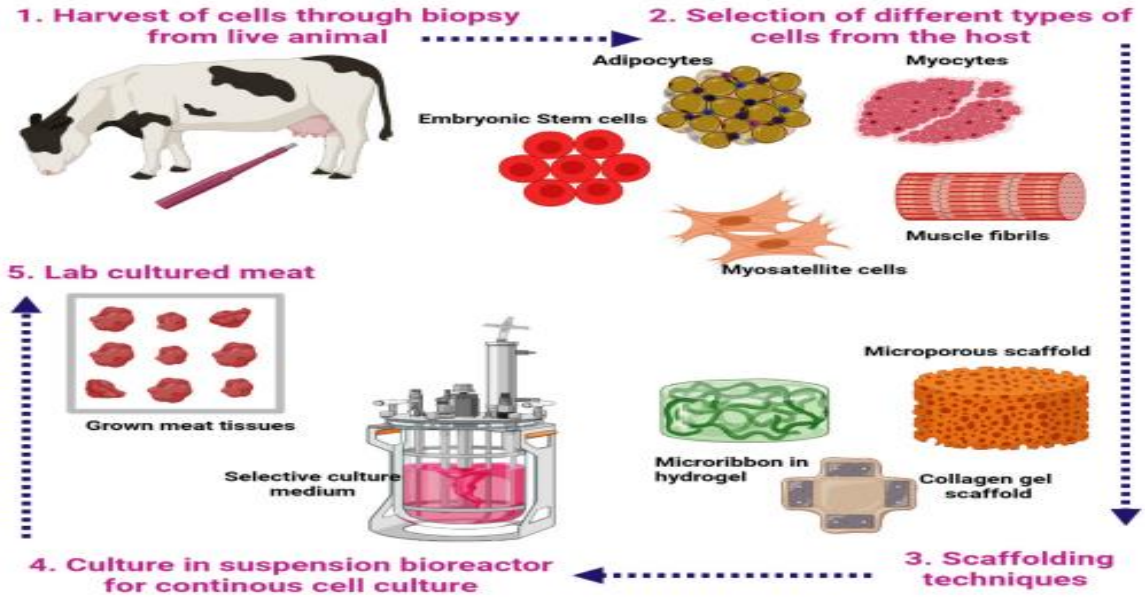
Embryonic Stem Cell-ESCs are cells that can produce meat in large quantities in vitro, because these cells can reproduce without restrictions (Hamdan et al., 2018). Embryonic Stem Cell-ESCs are also expected to be able to produce meat that can meet the needs and demands of humans worldwide (Hamdan et al., 2019; May, 2013) , so that the use of these cells is very possible to use and develop (Izhar Ariff Mohd Kashim et al. al., 2023) . However, the use of ESCs for artificial meat raises ethical issues for the embryos used to produce cultur meat. In addition, these cells can also turn into muscle cells and cancer cells which cause tumors to grow in the meat of these cells when they have developed into meat. (Kshitiz, nd; Langelaan et al., 2010; Samadhikuchaksaraei, 2014) .

The second source is Myosatellite Cells which is a part of ASCs. These cells have the ability to renew themselves and reproduce properly. However they can only differentiate into muscle cells. Myosatellite cells can be taken from animal cells and can be developed into muscle cells (Izhar Ariff Mohd Kashim et al., 2023; Wagers & Weissman, 2004). Until now, Myosatellite Cells have been the best choice for artificial meat, because it doesn't need any other material to push it into muscle cells. In fact,

these cells can be distinguished from several types of livestock such as cows/oxen (Dodson et al., 1986), pigs (Wilschut et al., 2008), chickens (Yablonka-Reuveni et al., 1987), fish (Powell et al. ., 1989), and goats (Dodson et al., 1986).

The use of ASCs or Myosatellite Cells as material for culturing meat has several drawbacks, including Myosatellite Cells are not easy to obtain in the animal's body, besides that these cells also have a limited capacity to reproduce, usually only up to 50 times. This phenomenon is called the Haylick Limit. Cultivating cells for a long time can produce cells that are dangerous , these cells are also difficult to separate from the animal of origin and usually require further processing in the laboratory. (Datar & Betti, 2010; Lazennec & Jorgensen, 2008) .

The image below is an illustration of the process for making in vitro meat produced from cell material as described above (Balasubramanian et al., 2021) .



In Vitro Meat Making Process

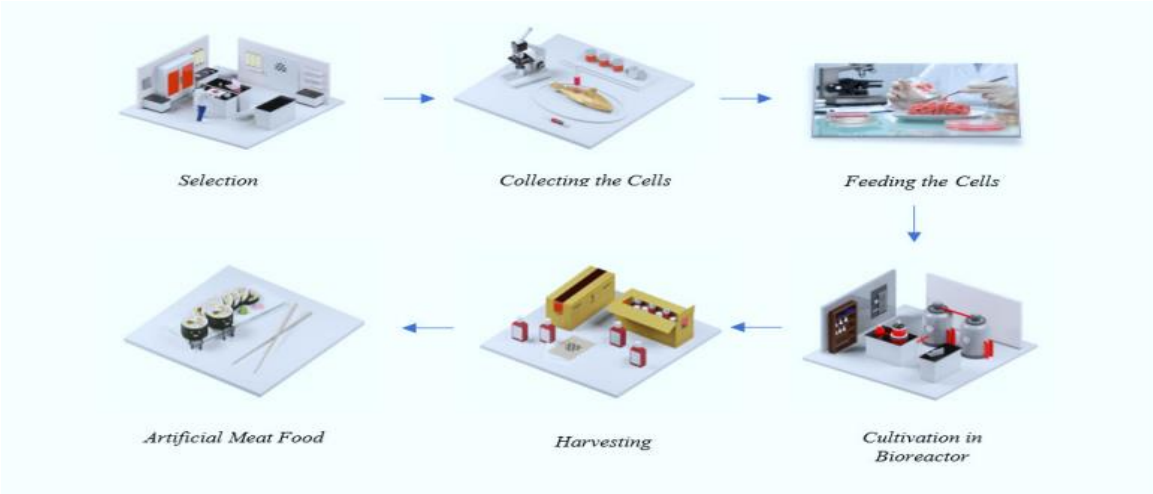
The company from the United States "Mamphis Meat" divides the phasing process for making in vitro meat into four stages, namely: collecting the cells, at this stage the process of taking cells from animals that are still alive or dead through a biopsy process is carried out. The structure of the meat consists of tissue structures such as muscle tissue, blood tissue, fat tissue, connective tissue, blood vessel tissue and nerve tissue. In this process, only muscle tissue and connective tissue are taken, then

the two tissues are put together in one place to be developed (Hasibuan & Muslim, 2022).

The second is feeding the cells, at this stage cells are grown, reproduced and maintained in an isolation tube or special laboratory culture media made of glass. In this stage, the cells will then be given various proteins, minerals, sugars, salts, amino acids, nutrients, vitamins and various other carbohydrates so that the cell tissues can be formed properly so that the meat is formed as desired (Hasibuan & Muslim, 2022). In this process the place must also be protected from contamination by fungi and other harmful microbes. In addition, the room temperature must also be maintained so that the development of cell cultures goes well.

The third is in the form of a cultivation bioreactor, cells that have reproduced well will then be transferred to the bioreactor to be raised there. The success of meat in vitro at this stage is largely determined by strict parameter settings, such as regulation of physicochemical variables (pH), oxygen, temperature, biochemical inputs, nutrients and metabolites (Rodrigues et al., 2011). The success of maintaining this process is marked by the change of these cells into muscle and connective cells. After this process the cells will produce thousands of cells that form a lump of meat, this stage takes about two to eight weeks (Hasibuan & Muslim, 2022).

The fourth is harvesting the tissue, this stage is the final process, namely harvesting the results from the cells that have been formed into meat that has met the adequate density like conventional meat (Hasibuan & Muslim, 2022). The following below is an illustration of the process of making meat in vitro (Hasibuan & Muslim, 2022) .



In Vitro Meat Manufacturing Techniques

There are several techniques that can be done in the manufacture of meat in vitro. However, so far the production of in vitro meat has generally been carried out using 3 techniques, namely: scaffold-based, self-organizing, and 3D printing (Izhar Ariff Mohd Kashim et al., 2023). The scaffold-based technique was originally carried out to separate the MCs stem cells that were to be used from the bodies of farm animals, be it cattle, goats or others. Then it is placed in a container or bioreactor containing the appropriate culture medium (Bhat et al., 2014). The culture medium must contain nutrients and chemicals that are the same as those in the animal's body (in vivo) (Datar & Betti, 2010; Schneider, 2012).

Collene tissue cells are also used in scaffold-based processes. After multiplying within a few weeks or months the stem cells have turned into muscle cells and are attached to the scaffold frame that has been placed in the container or bioreactor that has been provided. After that, these cells will turn into muscle cells through signals around the medium. All cells will be combined and can be processed, cooked and eaten by humans (May, 2013). This scaffold-based technique can also grow muscle tissue cells on large edible sheets, where the muscle tissue cells can be processed after being rolled to a suitable thickness. This process can be used to produce processed meats that are ground, such as hamburgers or sausages, the meat may not be as structured as steak but the cells are easy to culture in the medium so that they can grow on their own (Van Eelen et al., 1999). This is the drawback of the scaffold-based

technique because it cannot produce meat like that of a bull's body in three-dimensional 3D form.

The second technique is self-organizing, highly structured meat such as steak can be produced through the creation of structured muscle tissue so that the meat can form itself (Bhat et al., 2014; Dennis & Kosnik, 2000) . This technique has been used by scientists led by (Benjaminson et al., 2002) who cultivated carassius auratus (goldfish) for a period of 7 days by mincing and placing the meat in a container containing suitable culture medium. Even though this meat can produce meat that is exactly the same as conventional meat, the meat produced through this process has the disadvantage of having no blood vessels in the meat. So that if left unchecked, the meat can turn into a poison that is harmful to health (Benjaminson et al., 2002; Dennis & Kosnik, 2000).

The last technique is 3D printing. This technique was introduced by Dr. Gabor Forgacs in 2011 (Izhar Ariff Mohd Kashim et al., 2023). Three-dimensional (3D) or four-dimensional (4D) organs or bioprinting are based on conventional printing principles. The design uses computer assistance to create bio product models. The cells are sprayed onto the gel according to the design that has been made. Then during culture the cells coalesce to form bio products which can have the basic cellular structure and vascularization to circulate blood (Boland et al., 2003; Hopkins & Dacey, 2008). This 3D printing technique is the most effective technique for creating anatomically identical organs or tissues. However, this technique is sensitive to humidity and temperature, so temperature and humidity must really be regulated and paid attention to so that the meat produced is effective (Mateti et al., 2022).

In Vitro Meat Industry Legal Analysis

Concept of Food in Islam

The concept of food that is permissible for Muslims to eat must be clearly halal based on sharia law guidelines in accordance with the Qur'an, Sunnah, the agreement of the ulama (ijma') and analogy (qiyas) (Izhar Ariff Mohd Kashim et al., 2023). But sometimes it is also used as a basis for determining the law of something based on ijtihad (Sahilah et al., 2016) . The concept of ijtihad at the present time is usually carried out by a group of scholars who are members of a clerical organization. This group of

scholars meets the established scientific standards. In several countries the designation is different, for example Indonesia is called the Majelis Ulama Indonesia (MUI), Malaysia has the Jabatan Kemajuan Islam Malaysia (JAKIM), Singapore has the Majelis Ugama Islam Singapura (MUIS) and others.

But literally when referring to the verses of the Qur'an that the food that is permissible for Muslims to eat contains two general principles, namely: halal and good to eat. As stated in surah al-Baqarah verse 168: "*O people! Eat from the lawful and good food that is found on earth, and do not follow the steps of Satan. Indeed Satan is a real enemy for you".* There are other surahs in the Qur'an that mention the concept of halal and good food, such as surah al-Ma'idah verse 88, al-Anfal verse 69 and an-Nahl verse 114. What is meant by "halalan toyyiban" is in the form of halal food sourced from something that is lawful, acceptable according to human nature, does not contain elements of doubt, and must be hygienic, safe and nutritious (Izhar Ariff Mohd Kashim et al., 2023). Therefore Muslims must follow the principles of food that is permissible to eat for the sake of their physical and spiritual health.

Halal food from halal sources means that the food must be legally obtained clearly from Islamic law, be it the Qur'an, sunnah, ijma' or qiyas. Halal food refers to halal sources and also in the form of one's own property, not the result of stealing, corruption, cheating, usury and other things that are prohibited by Islam. Food that is acceptable to human nature means that the human nature does not like something that is disgusting, such as fleas, lizards and caterpillars, so that is prohibited by the shari'at. So therefore the food must be "toyyiban" meaning something that is considered attractive and able to captivate the human soul (Muhammad Fahkhr al-Din al-Razi, 2000).

Meanwhile, (Muhammad Syasuddin al-Qurthubi, 2006) explains that food that is in accordance with human nature must be "toyyiban", namely food that is considered good and attractive by humans. Thus Muslims are prohibited from eating dirty food such as lizards. Substantially "toyyiban" food also means that it is not questionable food, that is, food whose halal and haram status is not known. The Prophet explained in his Hadith "In fact, what is lawful is clear and clear, what is unlawful is also clear and clear. Between the two there are doubtful matters, many

people do not know about. Whoever distances himself from it, he has saved his religion and honor, but whoever falls into it, he has fallen into something forbidden (Hadith of Muslim History) (Imam Abi al-Husain Muslim, 2014).

Acceptable "toyyiban" food means that it is also included in the category of hygienic, clean and safe for health. Food hygiene also means that the food is protected from uncleanness and dirt. (Ibnu 'Ashur & Muhammad al-Tahir, 1984) emphasizes cleanliness in the meaning of the verse about "halalan toyyiban". This means that safe and clean food does not harm human health. (Ismail Ibn Katsir, 1999) also states that "halalan is something that is lawful to eat" and "toyyiban" is good for the soul and there are no influences that can harm the body and mind". Hygienic food can also be seen in terms of its preparation and storage. Proper preparation and storage can prevent humans from foodborne illness caused by contamination of pathogenic bacteria, such as Salmonella Typhi, S. Paratyphi, Escherichia coli O157:H7, Bacillus cereus, Listeria monocytogenes, Vibrio cholerae, and V. parahaemolyticus. Individuals affected by these bacteria may experience diarrhea, vomiting, and dizziness (Izhar Ariff Mohd Kashim et al., 2023).

Halal and good food also implies that the food must be nutritious which can provide benefits for the physical and spiritual aspects. (Wahbah al-Zuhaili, 2002) states "toyyiban is a food that is beneficial for physical, spiritual, faith and spiritual health". The best food can prevent disease and can promote health to a greater extent. Halal and good food patterns also became activities that were practiced in the life of the Prophet Muhammad. Therefore "halalan toyyiban" food must contain the 6 elements described above as guiding concepts and instructions regarding food that is permissible for consumption by Muslims.

Halal In Vitro Meat for Consumption

Industrialization of in vitro meat is a new matter where previously there was no explicit law regarding whether it is halal or haram for consumption. As far as the author's observations, until now there has been no halal or haram fatwa on this matter from the association of scholars through the MUI in Indonesia, JAKIM in Malaysia or others. There is only a collection of several articles written and analyzed by previous researchers as the authors have reviewed in the introductory section. To answer this

problem there are two things that need to be considered, namely ESCs and MSCs materials as the basic ingredients used in making in vitro meat and serum which is used as a medium for growing in vitro meat.

ESCs stem cells are animal embryonic cells formed from the production of male cells and female egg cells. Based on these stem cells, previous studies by (Hamdan et al., 2018; Izhar Ariff Mohd Kashim et al., 2023) linked these ESCs with fetal law, so that their halal status must follow that of the fetal mother. Because indeed in the Hadith it is explained that: *"the slaughter of the fetus of an animal is included in the slaughter of its mother"* (Al-Tarmizi, 1996; Ibn Majah, 1998).

In language, the fetus comes from the word (*janna*) which means protected and hidden in the mother's stomach (Ibn Manzur & Ibn Ali, 1993). Hampari agrees with that, Abadi also defines a fetus as a child still in its mother's womb (Abadi Abu 'Abd al-Rahman, 2005; Al-Jawhari & Hammad, 1990; Ibn Abidin, 1994). The majority of scholars are of the opinion that it is permissible for the fetus to be eaten if the mother has been slaughtered first. However, some of them require that the fetus must be mature enough based on the appearance of its fur. However, if the fetus comes out alive, then the law cannot equate the fetus with the slaughter of its mother. This was expressed by several scholars from the Maliki school of thought (Ahmad Abd al-Rahman al-Qarafi, 1994; Al-Qayrawani, 1999; Ibn Rushd, 1988), Shafi'i (Al-Mawardi, 1994; Al-Syarbini, 1997 ; Imam al-Shafi'i, 2001), and Hanbali (Al-Buhuti, 2000; Ibn Qudamah, 1996).

The question is whether the fetus as intended by the scholars can be equated in law with ESCs as stem cells in in vitro meat production? From this problem the authors argue that ESCs cannot be equated with fetuses from a legal standpoint, even though the fetus comes from ESCs but at that stage it has not been said to be a fetus as intended by the scholars above. Because the stage that can be said to be a fetus is when the cell has formed as *a mudghah* (clot of blood) until it forms flesh and there is life in the fetus.

Other considerations are regarding *nutfah al-amsyaj* (liquid mixed), *'alaqah* (meat attached) and *mudghah* (lump of meat). The majority of scholars argue that *'alaqah* and *mudghah* are forbidden to eat because they are considered meat consisting of blood (Al-

Kasani, 1986; Al-Mawardi, 1994; Al-Syarbini, 1997; Al-Zayla'i, 1897) . The prohibition of eating *mudghah* is also explicitly stated in the Qur'an surah Al-Ma'idah verse 3. However, in the Shafi'i school there are those who say that *mudghah* can be eaten and there are also those who say that *mudghah* is forbidden to eat (Al-Mawardi , 1994). Regarding the ESCs that are used as stem cells, they are still in the *nutfah al-amsyaj stage*. The law of *al-amsyaj's nutfah* is sacred (Al-Mawardi, 1994; Al-Syarbini, 1997). Thus, it can be concluded that the ESCs used as stem cells to grow meat in vitro are sacred and may be eaten. Moreover, *the nutfah al-amsyaj* has turned into a clean and healthy lump of meat for consumption, provided that the ESCs used as material come from halal animals. Regarding whether the animal must be slaughtered beforehand, in the opinion of the authors, it will not have an effect on the halal meat of ESCs because it becomes a problem if these ESCs are equated with the law of the fetus.

However, if MCs are used as stem cell material to grow meat in vitro, then the animal source must come from halal animals and must be slaughtered first. Because the MCs process is a part of the animal's body that is cut. Therefore there is a connection with fiqh law here, namely regarding the limbs of animals that are detached while still alive, then it is considered a carcass, and carcasses are unclean and unlawful to eat (Al-Mawardi, 1994; Ibn Abidin, 1994; Ibn Qudamah, 1996). Thus, cultured meat whose stem cells come from MCs is halal to eat if the animal must be slaughtered according to Islamic law.

Conclusion

Industrialization of meat in vitro is the result of scientific and technological advances. Where meat can be produced without going through conventional livestock processes which contain a lot of emissions and take up land. There are two main sources that can be used as stem cells to grow meat, namely Embryonic Stem Cells (ESCs) and Adult Stem Cells (ASCs/Non-Embryonic Stem Cells) or MCs. Islam requires its adherents to consume halal and good food. Determination of halal and good must be in accordance with the Qur'an Sunnah, Ijma' and Qiyas or ijtihad of previous scholars.

In vitro meat sourced from Embryonic Stem Cel-ESCs is halal to eat with the condition that the ESCs must come from animals that are halal to eat, even though the

ESCs are taken when the animal is still alive it is still considered halal because ESCs cannot be equated with the law of a fetus. However, in vitro meat sourced from Adult Stem Cells-ASCs or MCs must be accompanied by animal slaughter because in the process these ASCs or MCs are taken from pieces of animal meat. So pieces of animal meat are considered unclean if they are not slaughtered in accordance with Islamic law first.

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