

Artificial meat in the structure of halal meat products: legislative and legal status, technologies, Russian and international experience

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Abstract. The issue of halal certification of meat and, in particular, “artificial” meat is quite relevant. If it has been solved in principle for traditional variants of meat and meat products, the appearance on the market of a new form of meat, artificially grown in laboratory conditions, implies significant changes in the legislative and legal status of this product. Moreover, the requirements for both certification and improvement of its production technology need to be adapted. There are certain successes in both directions. This paper analyzes the level of solution of this issue in Russia and abroad.

1 Introduction

One of the fundamental components of the food culture that human communities develop is religion, usually symbolizing their heritage and the sociocultural aspects of ethnicity. Through food laws that impose or prohibit the consumption of certain foods, religion has a significant influence on the dietary habits of the population. For example, the life of a Muslim is regulated by a set of rules governing the actions permitted by the Shariah (halal).

The term “halal” is translated from Arabic as “permitted” and means “all that is allowed and permissible in Islam”. Non-Muslims usually associate this word with food that Muslims, who make up about a quarter of the world's population, are allowed to eat. These are predominantly residents of countries with a high Muslim component, the majority of which (more than 80% or about 1.5 billion people) live in 40 countries. The largest Islamic populations are Indonesia, Pakistan, Bangladesh, Malaysia, as well as countries that are members of the Cooperation Council of Arab States of the Persian Gulf. They are Bahrain, Qatar, Kuwait, the United Arab Emirates, Oman and Saudi Arabia. Consumers of halal products are also the population of “non-Muslim” countries. For example, in the United States alone, there are about 8 million people who consume halal products.

The issue of halal certification of meat is also relevant for Russia. First of all, the Islamic nations that inhabit the territory of the Russian Federation are the second largest in terms of population. In addition, it will potentially boost the export of Russian agro-industrial products to these countries.

2 Results and discussion

There are many halal standards for meat worldwide (GSO 993: 2015; OIC/SMIIC 1: 2019; HAS 23103: 2012 and MS 1500: 2019, etc.) representing different geographical areas [1], which can cause confusion for producers, especially those from non-Muslim countries exporting their products and wishing to certify them as halal.

The growing demand for halal labeling motivates meat producers to comply with the relevant standards because of the potential commercial benefits. However, given the above, such certificates issued by different organizations often differ in their requirements for these products. There is a need to establish the most unified halal standard possible, which will facilitate the activities of producers and increase consumer confidence in the product in question.

The appearance on the consumer market of an innovative product in the form of artificial meat has led not only to ethical, medical, environmental, cultural and economic discussions, but also to religious ones [2]. In particular, this trend has further complicated the problem of harmonization of existing halal standards and raised the bar of requirements in this direction of responsible organizations closely cooperating with the authorities. It would be nice if official structures involved in the certification of halal meat would share their opinion on this variant of lab-grown meat; for example, through “Ijtihad” and bring it to the public.

The interest of the official authorities of the Russian Federation in halal products was documented as early as October 2, 2017, when by order of the Federal Agency for Technical Regulation and Metrology (Rosstandart)

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the Project Technical Committee for Standardization (PTC 704) “Halal Products and Services” was formed. The key task of the committee was to create a regulatory and technical framework that takes into account the specifics of halal products and is aimed at eliminating falsified and counterfeit products from the market. In addition, the PTC envisages international cooperation, study and implementation of the experience of similar international organizations in Russia. The development and implementation in Russia of standards for halal products and services similar to international standards will allow Russian halal products to be exported. The PTC includes representatives of federal and regional executive authorities; certification bodies; industrial enterprises; scientific, administrative and public organizations.

In Russia today, 3 national standards related to the halal brand are used:

- GOST R 70401-2022 “Halal food production processes. General requirements for halal food products”;
- GOST R 70405-2022 “Halal products and services. General terms and definitions”;
- GOST R 70402-2024 “Conformity assessment. Requirements for halal certification bodies”.

The first two were approved on December 30, 2022 by orders of the Federal Agency for Technical N 1737-st. and N 1738-st; the third was approved on March 29, 2024 by order N 383-st.

GOST R 70405-2022, effective from March 1, 2023, was developed by the Private Institution of Higher Education “Russian Islamic Institute” (RII), while in the development of GOST R 70401-2022 (effective from June 1, 2023) participated, in addition to the Russian Islamic Institute, also Limited Liability Company “International Center for Standardization and Certification ‘Halal’ (LLC ‘ICS&C ‘Halal’)” and Joint Stock Company “Republican Certification Methodological Center ‘Test-Tatarstan’ (JSC RSMC ‘Test-Tatarstan’)” took part in the development of GOST R 70401-2022 (effective from June 1, 2023).

GOST R 70402-2024 became effective on September 1, 2024 and established requirements for the activities of certification bodies for halal products, processes and services.

According to these standards, raw materials for the production of halal products can be food resources of animal, plant, microbiological, mineral, artificial or biotechnological origin. At the same time, the absence of prohibited components in raw materials must be confirmed by official certificates. None of these standards mentions meat grown in laboratory conditions.

Since 2023, the Russian Quality System (Roskachevo) has been a member of PTC 704. Almost immediately on its basis, a national Center of Competence in the field of halal products and services was established, whose activities include standardization, certification, product quality monitoring, as well as promotion of certified Russian halal products in the domestic market and abroad.

The range of the Center's tasks includes:

- creation of an effective halal infrastructure in Russia;
- education in halal issues;
- provision of educational services in the halal sphere;
- analyzing trends and news in the industry;
- monitoring the quality of halal products and services;
- promotion of standardization in the halal sphere;
- development of a network of halal certification centers;
- international recognition of domestic halal standards and certificates.

In 2024, 8 draft national halal standards are under development, including requirements for certification bodies and certification procedures. These documents will strengthen the entire halal certification system in Russia and ensure transparency and consumer confidence in products that conform to their religious beliefs.

Earlier, in January 2023, Roskachestvo registered the voluntary halal certification system with Rosstandart, and in April, for the first time in our country, the Roskachestvo-Halal certification body received accreditation from the Federal Accreditation Service (Rosakkreditation).

Although meat has always occupied a special place among a fairly wide range of halal products, it is not emphasized in the legislative and legal field. Meat is called halal if it is produced and cooked according to the Shariah. The question of whether meat grown in laboratory conditions is halal is rather complicated and, probably, the relevant discussion will be lengthy, since even today the possibility of compliance with some of the obligatory provisions (pillars) of Islam remains open.

Currently, the only countries where laboratory-grown meat is sold in small quantities are the United States and Singapore.

Back in 2018, Future Meat Technologies from the US launched artificial meat (beef). In the U.S., approval for the sale of artificial chicken was granted in 2023, while in Singapore it became available for retail sale from May 16, 2024. Producer companies continue to seek a halal ruling for their products and international recognition as such.

In January 2024, the Israeli Ministry of Health authorized the sale of artificial meat (beef) produced in laboratory conditions from calf stem cells by Aleph Farms Ltd, a company that has developed its own technology for this production. The company found a way to produce artificial meat with the texture, flavor and juiciness of natural meat. For this purpose, it was combined from simultaneously cultured four types of cells: muscle, connective, vascular and fatty tissues. The process was completed using 3D printing technology. Although the product is planned to be sold domestically in Israel, the company aims to become the “first halal-certified” company to produce lab-grown meat. However, given Israel's escalating relations with Muslim countries, it is unlikely that the population of the latter can be considered as potential consumers of this product.

In July 2024, the UK will also be authorized to sell lab-grown artificial meat (at the first stage, it will be used only in animal feed).

Although the sale of such meat is not yet authorized in China, back in January 2022, the Ministry of Agriculture of the People's Republic of China published a five-year agricultural plan in which the cultivation of artificial meat was mentioned among the sectors in which it should be actively involved. Moreover, in 2023, the Shanghai-based company CellX launched a pilot production of artificial meat for local restaurants and by 2025 plans to build a plant to produce hundreds of tons of this product per year with the prospect of supplying it to Singapore and the United States.

In Russia, similar work is also underway, although the achievements are quite modest. In 2018, the first domestic startup in the field of cultured meat – ArtMeat, which specializes, in particular, in horsemeat – appeared in Kazan. In 2019, the Ochakovo Food Ingredients Plant claimed to have successfully grown artificial beef, but the project was put on hold in 2021 due to the pandemic.

The emergence of artificial meat is seen by many scientists as a technological challenge, a revolution in food production. Its production process is constantly evolving, driven by both the companies producing it and the relevant research institutions. It is derived from animal cells grown in nutrient-rich culture media under controlled conditions. The method eliminates the need for resource-intensive industrial farming of farm animals and traditional slaughterhouses, while also matching the values of vegans, vegetarians and meat consumers. In essence, artificial meat provides a sustainable and ethical alternative to traditional meat production. Nevertheless, there are fundamental differences between this meat and conventionally produced meat, which raises questions about its halal character. Its recognition under the halal approach depends on careful adherence to the principles of Islam. The main issue is the source of the cell lines and the processes involved in their creation and cultivation.

At the same time, as noted above, there is currently no uniform standard of “halal meat” in the world, even in relation to meat obtained by traditional methods. Foreign Islamic religious scholars working with producers of such meat believe that it should be represented by animal species permitted by religious rules. This does not include carnivorous and omnivorous (primarily pigs) mammals and birds. Meat from domestic animals with split hooves such as goats, camels, buffalo, sheep and cattle is permitted. Of the poultry category, chicken, ducks, turkeys, pigeons and sparrows are allowed. This requirement is relatively easy to fulfill in the production of artificial meat.

The next condition is that lab-grown meat must come from an animal that has recently been slaughtered according to halal standards. This violates the idea of “no slaughter” that many artificial meat companies strive for. Meanwhile, this condition does not apply to parts of the animal such as feathers, hair and other parts that are not considered alive. Accordingly, one way around this problem is to use cells taken, for example, from chicken feathers, which contain the cells needed to create lab-

grown meat. For example, employees of the company Just from the USA have developed a technology for “growing” cells from chicken feathers; in this case, the bird is not killed. Also artificial meat can be produced by multiplying cells obtained from a small piece of muscle tissue. The chicken egg can also be considered as an object for obtaining cells, since it is in the early stage of fertilization. The meat grown from these cells under laboratory conditions does not contain blood, which also meets halal requirements. Moreover, there are many examples of cell lines derived from non-living organisms.

The next requirement for the artificial meat production process is that the overall product should not be contaminated with any non-halal materials, such as blood. In the case of slaughtering an animal according to Islamic standards, the blood that flows out is impure. A small part of it remaining in the meat after “correct” slaughter and blood drainage is not considered impure, because it does not flow out. Blood products used, for example, as the main ingredient (blood sausage) are also not allowed. According to experts, artificial meat can be considered halal if blood or its serum is not used in the process of its cultivation.

For example, in February 2024, the Committee of Religious Rulings – fatwas of the Islamic Religious Council of Singapore (Majlis Ugama Islam Singapura – MUIS) recognized lab-grown meat as halal, provided certain conditions are met: the cages must come from animals approved for Muslim consumption (e.g. chicken, but not pork) and no non-halal ingredients must be used in the production process. The fatwa was issued after months of deliberations by the ulema, who consulted with stakeholders including government agencies, academics and experts. In addition, the theologians visited local production of “lab-grown meat.” The fatwa committee emphasized the environmental and nutritional benefits of such meat, recognizing that its advantages outweigh its disadvantages.

The production of artificial meat using animal serum in the nutrient medium is actively criticized by Muslims and in recent years there has been active research on the design of serum-free synthetic nutrient media for the cultivation of eukaryotic cells. In addition, their use makes production cheaper; makes the process of obtaining cell biomass more controllable and significantly reduces the risk of contamination.

Already today, such media have been developed that allow to abandon this blood component, thus eliminating its disadvantages related to the impact on the final result. However, it should be recognized that these media are mainly developed for the cultivation of mammalian cells intended for the accumulation of viral material.

Ideally, serum-free medium should have a specific chemical composition and support the growth of different cell types. However, such a universal medium does not exist and a special individual composition is developed for each cell type. The latter is a factor that has a great influence on cell metabolism.

At the same time, while the composition of basic (basic) nutrient media (MEM, DMEM, 199, F-12, RPMI, 199, etc.) is known and is given in the catalogs of most

commercial companies, the prescriptions of specialized serum-free media are the property of the developing companies (Gibco, JRHbiosciences, HyClone, etc.) and are not available for widespread use. Approaches to the creation of serum-free environments are fairly typical. Various growth-stimulating components, including a mixture of amino acids, inorganic compounds, micro- and macronutrients, sugars, fatty acids, insulin, transferrin, etc. are added to a known base medium. However, the combination, percentage composition of the components varies.

In general, serum-free media are divided into three main groups:

- Serum-free media proper, allowing the inclusion of components of animal origin in their composition.
- Protein-free, but containing materials of undetermined chemical composition, hydrolysates, peptones, etc., are classified into three groups.
- Chemically defined nutrient media, which not only do not contain animal products, but include only components of a certain chemical composition.

For example, Gibco (Thermo FS) has developed a wide range of serum-free media for cell culture on an industrial scale. These use only components of non-animal origin, and instead of insulin and transferrin, non-protein compounds are used.

Another chemically defined serum-free medium, Eden from Bioengine, is designed for protein production in high-density CHO cell culture. There are some features:

- it does not contain cytokines, antibiotics, hormones, hydrolysates, nucleosides;
- it has no protein-peptide ingredients, glutamine, HEPES, phenol red;
- it adapts to a variety of commercially or independently selected CHO cell lines, as well as different types of culturing;
- it supports CHO-K1, CHOZN, Horizon, CHO-S, CHODG44 and other cell lines.

Russian scientists have also developed a number of serum-free nutrient media [3–5 and others]. During cultivation, they ensure the growth of cells that retain the morphology typical for the culture, form a monolayer on the 2–3 day of growth, and retain high proliferative activity.

The problem is also the need to constantly change the medium as the cells grow. Scientists are going to create a technology in which it will be purified and reused as if passing through the liver and kidneys of an animal.

While there are different approaches to growing meat in the laboratory, in general the process is divided into three steps:

1. First, cells prone to rapid multiplication (proliferation) are harvested. These can be embryonic stem cells, adult stem cells (hematopoietic and mesenchymal), myosatellite cells (muscle stem cells) or myoblasts. At this stage, an animal (or perfectly preserved cells, but it has not been gotten to that point yet) is required. Pluripotent cells (capable of differentiating into all cell types except cells of extra-germinal organs) proliferate faster than others do, but

they have not yet differentiated into specific cell types, which raises the problem of “splitting” cells (differentiating into the wrong cell type) and the need to direct their growth in a certain way.

In this respect, “mature” muscle cells – explants – are better suited, as they have already formed as a cell type necessary for production. Unfortunately, explants do not proliferate well under in vitro conditions. Moreover, when using tissue explants, there is a high probability that a fraction of cells will die off due to the inaccessibility of nutrients to them, since tissue implies a cluster of cells bound together by intercellular contacts. The dying cells may release toxic substances. In addition, the nutrient medium will be consumed for the growth of cell types other than muscle cells, resulting in a lower muscle cell content in the food product than when using a myoblast cell line as a starting point.

Mesenchymal stem cells can be derived from different tissues (bone marrow, adipose tissue, skeletal muscle, liver, placenta, etc.) and different protocols are used to culture them. Currently, there is great inconsistency among laboratories regarding the choice of nutrient media and the addition of a variety of factors for successful isolation and expansion of mesenchymal stem cells. Therefore, there is a need to develop a more accurate and standardized protocol for their expansion. This process is influenced by the base of nutrient medium, glucose and glutamine concentration in the medium, as well as passage density, adhesive surface properties, etc. [6,7]. Accordingly, the choice of nutrient medium serves as an important component of successful mesenchymal stem cell culturing [8].

The use of myosatellites and myoblasts, which are still able to proliferate at the required rate and have already differentiated to a sufficient degree, is promising. However, it is difficult to isolate, cultivate and maintain a dynamic proliferative state of myosatellite cells. Myocytes of skeletal muscle tissue successfully obtained by transdifferentiation (reprogramming) from widely available fat cells can serve as an alternative [9].

2. Next, the resulting cells are treated by adding proteins that promote tissue growth. Then they are placed in the culture room, in a bioreactor. It acts as blood vessels, supplying the cells with everything they need and giving them conditions for growth. The main nutrient of the cells is the blood plasma of the animal (most often – embryo). It is supplemented with a mixture of sugars, amino acids, vitamins and minerals. For muscle tissue to develop properly, it is grown under pressure, simulating natural conditions. Heat and oxygen are also supplied to the bioreactor. Essentially, the cells don't even realize they are growing outside the animal.

Once these cells have grown sufficiently, they undergo a process of differentiation and maturation. In addition to muscle cells-myocytes, the grown material may include other cell types such as adipocytes (fat cells) and fibroblasts (connective tissue cells), depending on the desired composition of the final product. This is accomplished by altering the composition of the nutrient medium to mimic the metabolic shifts that naturally occur during animal growth. For example, muscle cells

will be stimulated to fuse to form myotubes and begin to secrete muscle-specific proteins, resulting in the formation of muscle tissue. At the same time, fat cells will begin to accumulate lipids, which will improve the flavor and texture of the final meat product.

Ideally, nutrient media should not contain components of animal origin and their use should be abandoned; therefore, various alternatives are being sought. For example, a serum-free medium was developed that supported multiplication in turkey satellite cell culture [10]. In addition, there are various serum substitutes that are good alternatives. For example Ultrosor G is one of many commercially available substitutes. A serum-free medium made from maitake mushroom extract has been successfully used with a higher growth rate in it than that of fetal bovine serum [11].

Myocytes should be grown under aerobic conditions to prevent acidification of the culture medium by lactic acid. Cell viability is positively correlated with the oxygen gradient in growing myocyte cultures, so oxygen transporters are likely to be required to maintain oxygen concentrations high enough to prevent hypoxia and acidification.

However, growing muscle cells require not only proper nutrition but also appropriate growth factors – polypeptides that support various terminal phenotypes (physical characteristics of the animal or its tissue at the final stage of development) and regulate stem cell differentiation and proliferation. Some of these are synthesized and released by muscle cells themselves, and in tissues are also provided by other cell types locally (paracrine) and nonlocally (endocrine). The liver is the major source of circulating insulin-like growth factor I. It is theoretically possible to develop appropriate co-culture systems so that liver cells (hepatocytes) provide the growth factors needed to produce cultured muscle, i.e., “meat from a test tube.” Typically, researchers induce differentiation and fusion of myoblasts by reducing mitogenic growth factor levels. The proliferating cells then begin synthesizing insulin-like growth factor II; the cells differentiate, and multinucleated myotubes are formed. The transforming growth factor β , bone morphogenic proteins and fibroblast growth factors can also be used as growth factors.

This implies the need for a system in which the composition of growth factors in the medium can be changed. The production of artificial meat will also require the development of new bioreactors capable of maintaining a low degree of deformation in the substance structure (so-called “shear”) and uniform distribution of various substances necessary for growth in large volumes. NASA rotary (rotating) bioreactors have often been used in cell culturing. Their main advantages are that the cells are almost continuously in suspension, “shear” of the fluid is minimized, and the suspension allows tissue culturing up to 1 cm. Meanwhile, theoretically, scaling up to industrial reactor sizes does not affect the physics of the system.

Nevertheless, a prototype bioreactor suitable for mass production cell culture has not yet been developed. For

example, the huge bioreactors used in the pharmaceutical industry are supposed to be abandoned in favor of smaller (and incomparably cheaper) bioreactors. Therefore, it will be possible to produce artificial meat not in one ultramodern plant, but in many small farms, which will significantly reduce costs.

In addition, other cell types, such as adipocytes, which are chemical messengers to provide the growing muscles with information about their structure, must be grown at the same time. Finally, muscle tissue must be physically stretched or “exercised” in order for it to develop properly.

3. To make meat three-dimensional rather than flat, laboratories use a kind of “scaffolding.” Culturing uses an edible scaffold to form a three-dimensional structure that supports tissue formation, much like the extracellular matrix does in a real organism. The resulting cultured product can be produced for a very long time.

In addition, cultured artificial meat needs preservatives like sodium benzoate to protect it from fungus. In addition, collagen powder, xanthan, mannitol, antibiotics and so on are used at different stages.

3 Conclusion

Given the impossibility of using animal blood serum in nutrient media for the production of “artificial” meat, and the media available today in the arsenal of biotechnologists are designed for the accumulation of viral material, it is necessary to intensify the development of serum-free composition for the cultivation of specifically myocytes.

There is a need to create, at least in the Russian Federation, a document similar to GOST, regulating the production of “artificial” meat, claiming the status of “halal”.

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