



A Jewish Religious Perspective on Cellular Agriculture

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Clean Meat is an emerging technology which promises to revolutionize the global food market. Alongside technological developments, the social impact of this innovation is being explored. Consumer acceptance will depend on multiple factors. For Orthodox Jews, the critical question will be whether the new food can be defined as kosher. In the absence of an exact precedent in Talmudic case law, scholars have begun to examine which set of principles would govern the status of the new meat product. Traditionally, meat is permitted for kosher consumption only when it derives from a kosher species which has been kosher slaughtered in accordance with strict regulations. There is room to suggest that this same set of rules would determine the status of any product derived through cellular agriculture, and thus the source cells would have to be extracted from a kosher species and only after kosher slaughter. Another approach would be to view the process as so different from the traditional growth of meat that it may be defined as kosher, even where traditional meat would not. Three determining factors will be: (1) the source of the original cells from which clean meat will be produced (animal species and cell type), (2) the nature of the growth medium, and (3) the exact nature of the process involved, which will determine whether the final product is considered a “new entity” or merely an “inheritance” of the starter cells. An authoritative ruling must be based on an in-depth appreciation of the scientific methods involved.

Keywords: clean meat, cultured meat, cellular agriculture, kosher, Orthodox Judaism, consumer acceptance, slaughter

INTRODUCTION

Clean meat also known as cultured, cell-based, or lab-grown meat (amongst other names) refers to a meat product created entirely in a lab through methods of cell culture and tissue engineering, as opposed to muscle tissue which grew in an animal (*in vivo*). Public interest in such a concept was propelled forward in 2013 when Professor Mark Post presented the world's first lab-grown hamburger at a public media-showing in London (Mattick and Allenby, 2013). In the aftermath of the media storm surrounding that event, societal implications of this nascent product began to be explored (Petetin, 2014; Verbeke et al., 2015). Amongst the various issues surrounding regulation and consumer acceptance, the question has been raised as to whether such a product would receive kosher (permitted for consumption under Jewish law) status (Purdy, 2018b). Such a question is of primary importance to Orthodox Jewish consumers, who barring such certification, would not buy and consume any such product. However, the question can be of broader interest as well, due to the indirect effect such certification might have on broader regulatory and health and safety concerns (Lytton, 2016; Jacoby, 2018). The kosher question becomes especially significant when bearing in

mind that, as of 2018, at least 4 companies involved in the development of cellular agriculture are based in Israel (Benjamin, 2018).

Since 2013, various articles have appeared in the mainstream media as well as in more scholarly literature examining this product from an Orthodox Jewish legal perspective (Bleich, 2013; Zhang, 2016; Purdy, 2018a). A wide range of views have been expressed, but an authoritative ruling on the subject is yet to emerge. There are two primary reasons for this. First, due to the fact that much of the discussion has been speculative. The prohibitive cost of the hamburger unveiled by Post et al. meant that mass production was still a long way off and several technological hurdles still needed to be overcome in order to begin production on an industrial scale (Post, 2014). A legal ruling must be based on a proper understanding of the technologies involved (Loike et al., 2018)—many of which are still under development, or protected under industry secrets. Second, when dealing with a completely new technology, decisors of Jewish law must decide from which precedents of Talmudic case law to draw upon in order to make a final ruling. In the absence of precise parallels, finding the appropriate case is challenging and can in many cases be subject to disagreement amongst scholars. It may still be a matter of time before a consensus view emerges.

Over the past several years, the prospect of clean meat has moved from the realm of the imagination to the world of developing technology. In December 2018, cell-based meat was named as one of Scientific American's top 10 emerging technologies for the coming year (Schaefer, 2018). Spurred by mass investment from private players and from industry, there has been a dramatic rise in the number of companies and lobby groups worldwide actively promoting and engaged in research and development (Carrington, 2018; Tyson, 2018).

The increased interest and upcoming viability of this product means that the religious discussion has taken on new significance as well. A final ruling will need to be based on a thorough understanding of the technologies and methods involved, but the principles and precedents to be drawn on can already now be carefully analyzed and thought through. This paper will outline those principles, without purporting to present an authoritative ruling on the matter.

SUSTAINABILITY

Present estimates regard the current system of meat production as unsustainable in the long-term. The UN estimates global meat consumption to increase by 73% by 2050, due to an increase in the global population, along with an increase in consumption of meat in countries such as India and China (Food Agriculture Organization, 2011). In order to provide for a sustainable food supply, either meat consumption needs to be reduced or alternative sources of protein must be found. Clean meat holds much promise in terms of the latter. It would require exponentially fewer livestock in order to produce, and may hold great ecological benefits as well

(Tuomisto and Teixeira de Mattos, 2011), although recent studies suggest these benefits may not be as great as initially anticipated (Lynch and Pierrehumbert, 2019).

The kosher market, although small compared to the global market, is a niche market which contributes to global meat consumption. Orthodox Jews, for religious reasons, will only purchase meat that bears kosher certification. Thus, the kosher meat market, despite its size, is significant in that it exclusively provides for this segment of the population. Whilst no official data exists for kosher slaughter, estimates show that in the UK for example, ~90,000 cattle, 90,000 sheep, and 1.5 million poultry are slaughtered annually for kosher consumption (Lever and Puig de la Bellacasa, 2010) out of ~2.6 million cattle, 10 million pigs, 14.5 million sheep and lambs, and 950 million birds that are slaughtered for human consumption in the UK (Humane Slaughter Association, 2019). It should be noted that the UK is amongst the five largest Jewish communities in the world, and thus kosher consumption will be significantly less in most other countries. In Israel, the kosher market can be estimated to be significantly larger. A 2016 report showed that 63% of Israeli Jews keep kosher at home and that 82% do not consume pork products at all (Pew Research Center, 2016). Furthermore, statistics show that consumption of meat per capita in Israel is significantly higher than in other Western countries. Israel is the highest consumer of poultry fowl per capita in the world and is placed 16% above the OECD average for total meat consumption per capita (OECD, 2019). It is probable that the significant place of meat in Jewish ritual and practice contributes toward these numbers.

Sabbath and festivals are characterized by festive meals, within which meat plays a significant role. Festivals are marked by a command to rejoice and the Talmud teaches (in a slight paraphrase) that “there can be no rejoicing without meat and wine” (BT Pesachim 109a). How binding this statement is has been discussed in the codes spanning the past 2000 years, but contemporary mainstream practice is to enhance the Sabbath and festivals with meaty meals (Yosef, 1977).

Rabbi A.I. Kook, first chief rabbi of mandatory Palestine, has noted there may be a far-distant future ideal of vegetarianism, however he is quick to note that this would only apply when humanity accepts it upon itself and is not to be thrust upon it by force (Kook, 1983). He even went so far as to advise his own son not to take on this level of stringency (Kook, 1965). Thus, for the kosher consumer it seems that meat is here to stay.

However, if clean meat were to provide a viable alternative it could be embraced by the Jewish community. Aside from the obvious global benefits, it could have added benefits for the Jewish community in that it has the potential to dramatically reduce the cost of kosher meat (Watson, 2018). It is hard to give precise numbers but estimates have shown kosher meat to be far more expensive than non-kosher meat. One study found that in the UK kosher meat is on average double the price of non-kosher meat (The Jewish Chronicle, 2016). Another survey conducted in South Africa found that kosher chicken averaged at 124 percent more expensive than non-kosher chicken (Katz, 2017). Kosher meat production involves a process of labor-intensive slaughter and checks which must be performed by expert personnel.

For this and other reasons, the output rate of kosher plants is much lower than that of non-kosher. Additionally, not all slaughtered animals and only certain parts of the animal can be supplied for kosher trade. These reasons combined account for the discrepancy in price between kosher and non-kosher poultry and meat (London Board for Shechita, 2019).

Clean meat would hopefully also go a long way to solving the sustainability issue of the global meat market (Post, 2014) and the kosher market specifically (Weitman, 2013). However, these benefits for the kosher market hinge on the question of whether the product would be permitted by Jewish law according to traditional principles of Talmudic extrapolation. In other words the big question is: will clean meat be kosher?

CLEAN MEAT

In broad terms, the stages involved in the production of clean meat are: the extraction of stem cells from an animal (or the extraction and conversion of other cells to pluripotent cells), proliferation of the cells in a suitable medium, differentiation of the cells into muscle cells (and possibly other cell types that are typically found in “natural meat”), and their growth via scaffolding (Bhat and Fayaz, 2011; Post, 2012). To date, peer review literature on the exact details of the procedure is sparse; however it stands to reason that there are differences between various companies and methods of production. One issue which has been discussed at length is the type of cells to be used as starters.

Stem cells are often used in the production of clean meat as they offer two enormous advantages over other cells, namely their ability to proliferate, and their ability to differentiate into various cell types (Bhat and Fayaz, 2011).

To this end two different types of stem cells have been discussed for the production of clean meat. Embryonic stem cells which carry the advantage of a much greater proliferation ability (Bhat and Fayaz, 2011), however differentiation is more problematic (Schneider, 2012). Alternatively, adult stem cells are easier to differentiate to the desired tissue type, but their proliferative ability is more limited (Post, 2012). In the case of the stem-cell hamburger mentioned above, myosatellite cells were used as the starter. These are adult stem cells found in muscle tissue. The distinct advantage of this type of cell is their self-differentiating ability toward muscle cells (Post, 2014).

VARIATIONS IN PRODUCTION METHODS

Primarily due to its widespread media coverage, Professor Post’s stem-cell hamburger has been the starting point for most scholarly and lay articles examining the Orthodox Jewish perspective on cellular agriculture. However, at present many more companies are engaged in the race to bring a product to market, and the products being explored come from a range of animals including cows, chicken, duck, and fish (Carrington, 2018). Variations in the species of animal from which cells are extracted, as well as the type of cells which are used as starters could have vast implications for the product’s status under Jewish law. As previously mentioned, in the case of Post, the starter

stem cells were myosatellite cells, which originate in the edible biomass of muscle tissue (Post, 2014). By contrast, at least one company that claims to be producing cultured chicken based on cells from the tip of a feather (Cook and Morris, 2018). At least regarding the laws of meat and milk, Jewish law differentiates between edible and non-edible parts of an animal (i.e., regarding the prohibition of cooking meat and milk together, the inedible parts are not considered meat). The same might be true regarding the use of those cells for cellular agriculture.

NON-TRADITIONAL MEAT IN RABBINIC LITERATURE

Remarkably, the concept of non-traditionally grown meat has a precedent in ancient Jewish texts, however these passages are of a non-legal nature (*Midrashic* or *Aggadic* in Rabbinic jargon). The Talmud tells a story of “miracle meat” which fell from heaven and would not be subject to the ordinary mandate of ritual slaughter (BT Sanhedrin 59b). Commentaries on the Torah also describe the creation of animals through mystical methods which would likewise not require ritual slaughter to be eaten (Leibush, 1973). Some have suggested relying on these sources as a precedent for the clean meat discussion and expanded their scope to include and permit any “meat” not produced in the conventional way of muscle tissue which grew as part of a living animal (Ryzman, 2014). However, to us the connection seems a tenuous one. Cellular agriculture is far from miraculous, rather it is a scientific process which occurs in a laboratory by natural means. In addition even if one were to claim a similarity, it is doubtful whether these sources bear any legal weight toward our discussion.

Indeed when extrajudicial sources such as these and others are brought to the debate, a word of caution may be needed. Cellular agriculture carries the potential for profound benefits both from an ecological and societal perspective (Tuomisto and Teixeira de Mattos, 2011; Post, 2014). These benefits are well in line with Judaism’s dictum of preserving the environment and not unnecessarily damaging the world, however this does not automatically necessitate a permissive ruling on the kosher status of the product. Such considerations may be factored in, but cannot replace the need for a thorough legal analysis from first principles of the emerging technology.

WHAT MAKES MEAT KOSHER?

A more appropriate place to begin the discussion would be regarding the requirements for ordinary meat to be kosher (permitted under Orthodox Jewish dietary laws). In order for meat to be kosher, two conditions are needed (Zivotofsky, 2010):

1. The animal species from which the meat is derived must be one of those deemed permissible for consumption by the Torah. For animals that includes all ruminants with fully split hooves, while for fowl it is limited to a specific list.
2. The animal must undergo a process of kosher slaughter (*Shechita*).

The difficulty which arises when discussing clean meat is that whilst although biologically the cells are identical to those which comprise the muscle tissue derived from an animal, in this case the origin of the meat is from microscopic starter cells rather than from the muscle tissue (meat) of the animal itself. The conditions mentioned above apply to meat comprised of normally grown muscle tissue (*in vivo*). However, here we are discussing meat grown in a laboratory environment (*in vitro*). How does Jewish law view such an entity? There are two primary and one secondary issue(s) here which must be addressed:

1. How should the starter cells be viewed? As a significant meat or meat-like entity or perhaps as something else?
2. How is the culture method/production process viewed? Does it negate or change the status of the original cells if such are judged to be unfit for consumption?
3. The effects of the growth medium and any other additives (if applicable).

We will address these concerns one by one.

STARTER CELLS

The discovery of cells and stem cells in particular is relatively recent and thus ancient Jewish texts provide no explicit answer as to how the cells should be viewed. Satellite cells were first described in 1961 (Mauro, 1961), while the first isolation of pluripotent cells from mice was reported in 1981 (Evans and Kaufman, 1981). Additionally, the fact that we are dealing with a product derived from an animal by no means forces the conclusion that it is to be viewed as a “meaty” substance—milk and eggs are classic examples of products derived from animals but which do not have “meat” status themselves. Eggs are considered “parve” foods (neither meat nor milk) while it is strictly prohibited for milk to be cooked or eaten together with meat (Shulchan Aruch, Yoreh De’ah 87). Furthermore, there may be precedent for animal derivatives which do not even retain the status (permitted or forbidden) of the source animal from which they are derived (Rosh, BT Brachot 6:35). There is however great room to suggest that the cell does retain the species identity from which it was taken.

In summary, it may be said that there are 3 options for how to view the starter cells when examined under the lens of Jewish law:

1. Meat (or meat derivative)
2. Non-meat derivative from the animal species
3. Non-food substance/insignificant.

Meat Derivative

The difficulty in viewing the original cell as meat is that quite simply it is not. Before culturing and tissue engineering the cell cannot be cooked or consumed and is certainly a long way off from the definition of muscle tissue. However, the paradox lies in the fact that the cell does in fact constitute the basic component of what comprises meat. It should be stressed that this is true only when dealing with myosatellite cells. Should the cells be taken from other parts of the animal which are inedible or otherwise not considered “meaty” this may not be the case.

Nonetheless, viewing the original cells as a meat entity means that the normal rules governing meat would apply to it. The main concern this raises is that even meat from a kosher species is forbidden for consumption until the animal has undergone ritual slaughter. Theoretically cells can be extracted from a slaughtered animal but it remains to be seen whether this will be done in practice. The preferred method at present for both scientific and societal reasons is to extract cells (harmlessly) from a living animal (Post, 2014).

Limbs taken from a live animal are prohibited for consumption under Jewish law (BT Hullin 102b). While there is room for nuance in this law, and it can well be argued that stem cells cannot be classified as a “limb,” an extension of this law bans the consumption of any flesh from a living animal (Maimonides, Laws of forbidden foods 5:2). This would be problematic should the cells be viewed as meat or a fleshlike entity (Ariel, 2016). Others have dismissed this claim stating that the cell is too small and dissimilar to actual flesh for the prohibition to apply to it (Ryzman, 2014). It should be stated that although the Talmud differentiates between a piece of flesh smaller or greater than the size of an olive, the codes state clearly that even the smaller amount whilst not subject to a penalty, is still forbidden for consumption nonetheless (Shulchan Aruch, Yoreh De’ah 62).

Non-meat Derivative

There is a principle in the Talmud that “that which derives from an impure species is similarly considered impure” (BT Bechorot 5b). Several examples are provided in Rabbinic literature for the application of this principle (Maimonides, Laws of forbidden foods 3:6). Significantly they include both non-meat derivatives such as milk and eggs, as well as a complete animal (of a kosher species) born to a non-kosher parent. Thus, irrelevant of the discussion mentioned in the previous paragraph, a cell whose source is from a non-kosher animal would be prohibited, so long as it is judged to be a significant entity—meatlike or not. Only viewing the cell as an insignificant would conceivably allow for the possibility of kosher clean meat sourced from a non-kosher species. Despite widespread media interest in the possibility of kosher pork (Purdy, 2018a), the majority of scholars currently lean against this view (Student, 2018). In any event this does not pose a problem to the viability of a kosher clean meat product, as the vast majority of production is sourced in kosher animal species (cows, chicken, and duck).

Insignificant

There is a line of thought to suggest that the starter cells could be considered completely insignificant (Ryzman, 2014). This is based on the principle in Jewish law that credence is not given to that which cannot be discerned by the naked eye. Thus, for example microscopic bacteria are not forbidden for consumption, despite lacking the signs normally needed for kosher species (Aruch HaShulchan, Yoreh De’ah 84:36). Similarly, it has been suggested, the cell which is microscopic in nature is deemed insignificant and consequently whatever entity follows from it would be permitted, regardless of its source (Ryzman, 2014). However, there is great room to distinguish between the case of clean meat and that of microorganisms.

Regarding the latter, the organisms are microscopic from beginning to end and are never recognizable by the naked eye. Not so in the case of cellular agriculture. Although the cells are microscopic to begin with, those same cells are what transform into the final product which is very clearly recognizable to the eyes and tastebuds. Indeed the subjective importance given to the cells through the process of manipulating them in a lab may be enough to render them significant despite their microscopic size (Bleich, 2013).

CULTURE METHOD

The second question that needs to be addressed is whether, even if the original cells are deemed forbidden for consumption, it is possible that the process of culturing and tissue engineering can cause them to lose their original status. This is not uncommon in Jewish law. Two precedents come to mind:

1. Nullification

There is an accepted principle whereby if a forbidden substance becomes (inadvertently) mixed with a permitted substance, the entire mixture remains permitted. This occurs only if the forbidden substance is unrecognizable in the new mixture and is to be found in a negligible ratio (Maimonides, Laws of forbidden foods ch. 15).

2. A new entity

There are several examples in Jewish dietary law whereby a forbidden substance is rendered permitted once it becomes a new entity. The Rabbinic jargon for such an instance is “panim chadashot” literally translated as “a new face” (Rosh, BT Brachot 6:35). This has been the qualification used by decisors who have permitted gelatin produced from non-kosher animal sources (Yosef, 2005).

Both of the above arguments have been put forward to advance the permissibility of clean meat. Yet neither are without refute. Regarding the nullification point, as a general rule most substances are nullified in a ratio of 60 to 1, however certain substances are deemed so significant that they render the mixture forbidden, no matter what their ratio (Shulchan Aruch, Yoreh De’ah 87:11). It seems likely that starter cells from which meat is produced would fall under this category. However, even more significantly, it is questionable whether it would be correct to deem a clean meat product a mixture at all, when it is really just a proliferation of the original starter cells (Ariel, 2016). Scholars have pointed to several Rabbinic texts which address the proliferation of a substance as having the same status as the original substance too (Ariel, 2015).

As per the second point of “panim chadashot,” certainly when dealing with myosatellite cells it seems difficult to suggest that the final product becomes a new and different entity from the cells from which it is derived. Indeed the entire purpose of the process is to create a product as similar in taste, texture and appearance to meat as possible (Post, 2014). However, were the starter cells to come from a different source, further removed

from muscle tissue, it may be possible to give more credence to such a claim. This is yet another example of how nuances in culture techniques could have serious implications regarding a final ruling.

GROWTH MEDIUM

Another matter which could cause concerns is the use of growth medium containing non-kosher ingredients. Nearly all growth mediums to date have been comprised (at least in part) of fetal bovine serum (FBS) (Reynolds, 2018). Blood, from which FBS is derived, is completely prohibited for consumption by Jewish law (Shulchan Aruch, Yoreh De’ah 66). The fact that such blood is “absorbed” into the cells could render the product prohibited even if no other concerns were to be found. Alternatively, the culture medium may be viewed not as an ingredient of the final meat product but as part of the “food” of the cells. In the same way that a kosher animal which has itself ingested non-kosher food does not become prohibited, the same might be said of the cells which produce clean meat. There is a similar argument regarding the production of enzymes in the kosher food industry (Weitman, 2018).

Nonetheless, this argument is likely to be merely academic in the near future. One of the main breakthroughs being attempted by researchers is the search for a suitable synthetic growth medium. This derives from reasons of sustainability, cost and health issues (Post, 2012). FBS poses a problem not just from a Jewish legal standpoint but from a scientific and societal standpoint as well.

It should be noted that any additives used will require kashrut supervision. This however is not unique to clean meat, rather it is standard to all products in the modern food industry (Jacoby, 2018).

CONCLUSION

Clean meat is an exciting nascent product with potential benefits for the global market, including the kosher consumer. As a completely new technology, there is no exact and defining precedent for its status in Jewish legal texts and thus scholars have begun to debate how it should be perceived. An authoritative final ruling on the matter will only be provided based on a full and transparent understanding of the process involved. The two major issues to be addressed are the source of the starter cells and the nature of the culturing and production method. Nuances between methods of production at various companies could have implications for the final ruling. In principle, a kosher clean meat product can be produced. It seems that the most widespread consensus amongst scholars would be achieved through the harvesting of cells from a kosher species, only after ritual slaughter.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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