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FOOD FOR A SUSTAINABLE FUTURE

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Abstract

In recent years, attention has been focused on the constant trend of population growth, and the consequent growing demand for food, which classic agriculture can no longer provide. Alternative food like insects, red seaweed, soy, and cell-based products are a sustainable way of changing our diet in order to minimize the environmental impact determined by greenhouse emissions, water, land, and energy use. Consumption of these alternative foods comes new industry vision of what the future of food will look like, and as a result with new regulations. Being novel foods, most people don't have enough knowledge and consider unnatural these new methods of producing them. Surprisingly, alternative foods are particularly rejected by Western societies, which proves that culture impacts a good amount of our beliefs. This current mini-review focuses on explaining what cellular agriculture is, what aliments are considered alternative food and whether we could reach a sustainable future by changing our diet.

Key words*: alternative food, cell-based meat, cellular agriculture, sustainable food, soy protein.*

INTRODUCTION

In recent years, increasing attention has been paid to agriculture and the development of the food industry. It has been brought to attention that classic agriculture will not be sufficient for our growing population without permanently damaging our environment.

In 2012, The Food and Agriculture Organization (FAO) of the United Nations predicted that by 2050, with an estimated population of 9.8 billion, the global demand for meat would be 76% more than in 2005 (455 M metric tons of meat), with only 2% agriculture land left. Therefore, the design and production of alternative foods have been intensively studied (Rischer et al., 2020; Rubio, et al., 2020). The European Commission designed the "Farm to Fork Strategy", to establish a healthier food system, indicating multiple actions, like reducing chemical pesticides by 50% and fertilizers by 20% and increasing ecological production from land use to 25% by 2030.

Currently, the food industry is known to be one of the major contributors to environmental problems, accounting for approximately 21-37% of global greenhouse gas emissions (Alae-Carew et al., 2021).

The aim of this review is to briefly explain what cellular agriculture is, what aliments are considered alternative food and whether we could reach a sustainable future by changing our diet.

MATERIALS AND METHODS

The methodology for the article collection contained the survey of one scientific data-base (ScienceDirect) for the published research data until March 2023. Only papers written in English were considered, dating as far back as 2011. The electronic search was performed using as specific keywords: alternative food, soy, red seaweed, insects resulting in a total of 371 articles, cellular agriculture, CBM, organoleptic properties resulting in a total of 11 articles, and cellular agriculture, CBM resulting in a total of 594 articles. Title and abstracts retrieved by these searches were screened for relevance and deduplication. The 25 selected articles were classified by article type (original research or review) and the validation was performed manually (by reading the entire article).

ALTERNATIVE FOOD

The 2018 Report published by the Intergovernmental Panel on Climate Change (IPCC) claims that by 2030, greenhouse gas emissions (GHG) need to decrease by up to 45% to avoid a 1.5℃ temperature increase; it is also stated that these problems are mainly caused by animal agriculture through land, water, and energy use, as well as methane emissions (Rubio et al., 2022).

In recent years it has been highlighted that consumers are looking for alternative foods for a sustainable future, with alternative proteins such as those extracted from plants, insects, algae and soy playing an important role in replacing animal proteins (Michel et al., 2021).

RED SEAWEEDS

Red seaweeds are one of the oldest and largest eukaryotic algae, with approximately 6500 known species, some of them being used around the globe for human consumption. They are very popular around Asian countries. For example, algae of the Porphyra genus are used as sushi wrappers (also known as Nori) (Rawiwan et al., 2022), and Palmaria palmata (dulse) is used as an ingredient in food processing (Mouritsen et al., 2013).

Red seaweeds have essential amino acids that can replace in a sustainable way animal protein. They provide high protein content, along with vital vitamins and minerals. Being spontaneously found in fresh water as well as marine water, they present an easy and sustainable way of cultivating them. Palmaria palmata could be cultivated on land, in pools and in the sea (Rawiwan et al., 2022).

Raw algae must be subjected to several treatments in order for the contained proteins to become valuable. Pre-treatment methods such as freezing, ensiling, and drying have been studied on red seaweeds, as well as different types of extractions. Every species of red seaweed has its different properties that require special extraction and harvest technique (Rawiwan et al., 2022).

INSECTS AS FOOD

It is well known that cows produce large amounts of methane, and it is currently debated whether it is still rational to maintain caw farms in the farming industry. Thus, scientists began to study insects as a reliable protein source. This idea was not well received at the beginning by western society, but at the moment there are 113 countries that are using insects as a source of proteins in different foods (Govorushko, 2019).

Looking from a sustainable point of view, insects are an efficient raw source, spending less energy and water and producing less GHG than other livestock. (De Carvalho et al., 2019). Most edible insects are harvested from their natural habitat (92%), a small part ise semi-domesticated (6%), and only 2% of edible insects are farmed (Madau et al., 2020).

As stated before, the main component of insects is protein. The protein content can range from 23% to 76% (found in the adult locust). Protein absorption, not that well tested, is believed to fluctuate from 77% to 98% for 78 species. (Hawkey et al., 2020). On the other hand, every year insects are killed to save crops that have at most 14% protein content, while the slaughtered insects contain up to 75% high-quality animal protein (Madau et al., 2020).

Moreover, there are studies that demonstrate that animals consume more food than they produce. An additional kilogram of beef requires 10 kg of feed, 2.5 for chicken and 5 kg for pork, respectively, while insects require merely 1.7 kg of feed (Govorushko, 2019).

SOY PROTEINS

Plant-based meat (PBM) is a completely vegetal product, obtained by transforming plants into products that resemble animal meat, and containing an optimal ratio of vitamins, fats, proteins, and minerals (Good Food Institute, 2021). According to New Nutrition Business, in 2020, PBM ranked 3rd in global food trends. The increase in the consumption of PBM has an important impact both on the environment, and on reducing the risks of diseases (Estell et al., 2021).

An excellent option to produce PBM is soy protein, because of its processing characteristic, good nutritional value and low cost. In order to obtain a soy-based meat alternative, the production process must include the addition of wheat gluten to bind and stabilize the structure of soy protein fibers, improve the flavor, but also to help build the structure (Wang et al., 2023).

Initially used as animal feed, soybean crops began to be used for the manufacture of oil and other types of food products only after the Second World War (Institute of Agriculture and Natural Resources, 2020). Currently, numerous products can be obtained from soybeans, such as: soy milk, which is a rich source of B12, D vitamin complexes; tofu acting similar to yogurt; soybean oil, soy sauce, etc. (Wang et al., 2023).

REGULATORY FRAMEWORK

Because alternative food is regarded as a relatively new concept, regulatory frameworks are not yet well established. Labelling rules are contained in the Food Information Regulation EU/1169/2011, which stipulates that every ingredient must be catalogued (Lähteenmäki-Uutela et al., 2021).

EU policy and regulations approve investment in alternative proteins; therefore, the European Commission announced in 2018 the EU Plan for Proteins, which urges the production of alternative foods for human consumption and offers alternatives to strengthen the development of plant proteins in the EU (Rubio et al., 2022).

Classical PBMs have been accepted for population consumption as they contain simple ingredients which have already been approved; in case of novel ingredients, they must be subjected to individual evaluation (Rubio et al., 2022).

Red seaweeds can absorb heavy metals due to their strong accumulation capabilities. To ensure safety, red seaweed must be thoroughly inspected in case of contamination during processing (Rawiwan et al., 2022).

Regarding insects, the new European Novel Food Regulation is applicable for whole insects, insect flour, and insect parts, since 2018 (Lähteenmäki-Uutela et al., 2021).

CELLULAR AGRICULTURE

FAO defines cellular agriculture as the cultivation of cells isolated from animals, followed by processing to produce food products that are comparable to the corresponding animal versions, such as meat, poultry, aquatic products, dairy products, and eggs.

Therefore, cell-based meat (CBM) deals with the production of meat from isolated and lab-grown cells, thus avoiding the current practice of animals' slaughter. The development of CBM is a complex process, consisting of several stages. Initially, muscle stem cells are harvested from animals and cultured in a suitable environment. Tissue engineers assemble muscle tissue, then adult cells are selected and placed on a framework into a bioreactor to grow. After that, the product is subjected to special treatments to achieve similar organoleptic characteristics to animal-based meat (ABM), and finally, CBM is ready to be consumed (Siddiqui et al., 2022).

In terms of nutritional value, it is well known that ABM contains minerals, vitamins, and amino acids, while there is no publicly available data for CBM. It is known that CBM contains proteins like collagen and fibrin, but, for example, vitamin B12 will have to be supplemented, being only produced by bacteria (Rubio et al, 2020; Siddiqui et al., 2022). In order for CBM to be as similar as possible to ABM there are three factors that are looked upon: texture, taste and appearance. The lack of myoglobin protein in CBM leads to the lack of naturally existing red colour in the ABM. To fix this problem, natural colorants like sugar beet or saffron are introduced in CBM production (Siddiqui et al., 2022). Texture can be replicated by eliciting alignment during the engineering process (Rubio et al., 2020).

Even if the production process is difficult and expensive, however, CBM has numerous benefits for humane health. While ABM is associated with antibiotic resistance and foodborne infections like Salmonella and Listeria, the process that cell-based meat must go under guarantees a sterile product, safe to consumption (Post et al., 2020).

Labeling cell-based meat is still a difficult task. In November 2022 in the Asia-Pacific region the word "cultured" has been approved. The EU as well as the United States have not concluded on how to differentiate animal-based meat from cell-based meat (Miyake et al., 2023). The first cell-based meat hamburger was made in 2013 by the CSO of Mosa MEAR, Professor Mark Post (Tuomisto, 2019). The first authorization for cultured meat was in Singapore, in December 2020 (Lähteenmäki-Uutela et al., 2021).

CONSUMER ACCEPTANCE

With The European Alliance aiming to make alternative food more accessible, many people are considering changing their diet to a plant-based one to safeguard biodiversity, animals' welfare, and human health. As studies show, the consumption of alternative foods is more common among women, adults, and people with higher education (Lehto et al., 2023).

According to a study conducted by Wendin & Nyberg (2021), consumer acceptance is highly influenced by familiarity as well as cultural settings. Red seaweeds, unlike other novel foods, are more easily accepted because of its minimal psychological barriers.

Consumers acceptance is troubling when we speak about insects consumption. Entomophagy (eating insects) is still uncommon in western societies and as long as it lacks acceptance it will be overlooked even if the food is safe and nutritious (Govorushko, 2019). One way to increase acceptance on entomophagy is by including insects in familiar products like flour, pasta, protein bars or burgers. Furthermore, we can provide information about their nutritional value and health benefits, as well as on the positive impact on environment sustainability (van Huis, 2021).

Regarding PBMs, for this industry to grow, broad consumer acceptance is needed. China registered a percentage of 95.6% of consumers accepting PBM, followed by India with 94.5% and the US with 74.7%. An increase in the consumption of plant-based meats has also been observed in the UK and in Australia (a study reported a five-fold increase over four years in PBM). In Europe, consumers are not only unfamiliar with plant-based animal products to a large extent, but also, those who know and consume this type of products, consider them much less sensory-appealing than the animal-based homologs. (Rubio et al., 2022). Nevertheless, a quarter of Finns are planning to reduce their consumption of beef and increase the consumption of plant protein in the next few years (Lehto et al., 2023).

A study made by Rolland et al. (2020) showed that the people informed about CBM were more easily led to acceptance than the people with poor knowledge about the topic. Therefore, one of the first measures that should be adopted is educating the population about the benefits of CBM, i.e. climate impact, human health, animals' welfare. A study carried out in 2011 showed that the development of the plant-based meat industry would lead to a decrease in water consumption by 82-96%, greenhouse gas emissions by 78-96%, of the energy consumed by 45%. However, these predictions were disproved in 2015, in a study that showed that there will be a slight reduction in the carbon footprint, but not as dramatic as previously estimated (Rubio et al., 2020; Tumisto et al 2011; Mattick et al., 2015).

CONSUMER ACCEPTANCE IN ROMANIA

Since there are currently no studies or public reports at the national level about the grade of acceptance of the population regarding alternative foods and products from cellular agriculture, we conducted a survey from 18th of March 2023 to 30th of March 2023 on 229 participants of different ages and levels of education.

Figure 1 presents the 12 questions regarding alternative food and cellular agriculture, and its acceptance rate in Romania.

The study was conducted on a population included in three age groups, between 18-30 years, 30-50 years, and older than 50 years. Figures 2, 3 and 4 show the responses of the persons questioned regarding the intention to try CBM, to change the animal protein in the diet with an alternative one or to give up animal meat in the diet. The survey showed that, out of 110 respondents aged between 18-30 years old, only 22.7% of them would try CBM; this percentage is small, but still 6.3 times higher than the one resulting from the answers given by population over 50 years old (in this case the percentage was 3.6% for 56 persons). The percentages remain approximately the same for the question related to the intention to change the animal proteins in the diet with alternative ones. Surprisingly, 41.8% of the youngest group were willing to remove meat from their diet.

Following this survey, we can conclude that in Romania, the total percentage of people who want to switch to alternative foods is unsatisfactory, but it is slightly higher for the young generation, who are more inclined to

accept such a change. This lack of desire to try alternative foods or products from cellular agriculture, indicated by the extremely low percentages obtained in the survey, can be explained on one hand by the lack of information on what alternative food or cellular agriculture means, how they are obtained, what are their benefits on human health, animals and environment, and on the other hand it is due to cultural customs, Romania being a country where traditional cuisine is mainly based on meat.

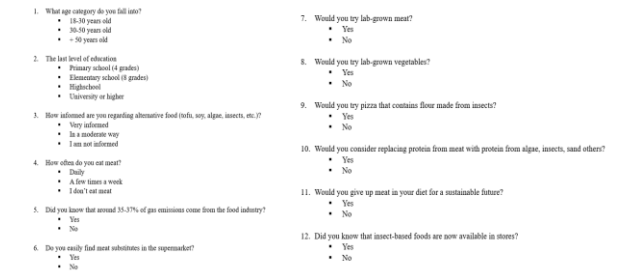
1. What age category do you fall into?
   - 18-30 years old
   - 30-50 years old
   - + 50 years old
2. The last level of education
   - Primary school (4 grades)
   - Elementary school (8 grades)
   - Highschool
   - University or higher
3. How informed are you regarding alternative food (tofu, soy, algae, insects, etc.)?
   - Very informed
   - In a moderate way
   - I am not informed
4. How often do you eat meat?
   - Daily
   - A few times a week
   - I don't eat meat
5. Did you know that around 35-37% of gas emissions come from the food industry?
   - Yes
   - No
6. Do you easily find meat substitutes in the supermarket?
   - Yes
   - No
7. Would you try lab-grown meat?
   - Yes
   - No
8. Would you try lab-grown vegetables?
   - Yes
   - No
9. Would you try pizza that contains flour made from insects?
   - Yes
   - No
10. Would you consider replacing protein from meat with protein from algae, insects, sand others?
    - Yes
    - No
11. Would you give up meat in your diet for a sustainable future?
    - Yes
    - No
12. Did you know that insect-based foods are now available in stores?
    - Yes
    - No

Figure 1. The survey made in Romania from 18th of March 2023 to 30th of March 2023 on 229 participants

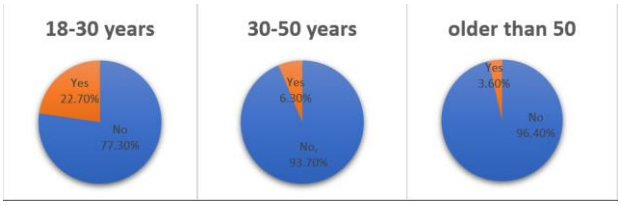

Figure 2. Willingness to try CBM in Romania

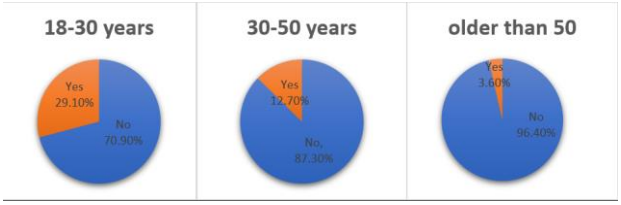

Figure 3. Willingness to change animal protein to alternative protein in Romania

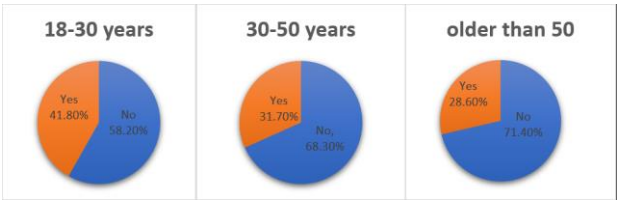

Figure 4. Willingness to remove meat from diet in Romania

CONCLUSIONS

Over the years there has been an increase in the use of water, energy, and land, as well as a growth in GHG emissions due to the food industry, therefore alternative food and cellular agriculture represent a sustainable choice, especially in terms of products from meat.

Red seaweeds are a sustainable alternative protein, are easy to consume and contain essential nutrients. Being already used all around the globe, all the regulatory framework already exists, and it is well accepted by people, especially by Asian countries.

Soy protein is the most accepted alternative food with a wide variety of aliments like, soy-burgers, soy sausages, soy-salami and so on. With further development of its organoleptic properties, it should attract a larger number of people.

Insects as food have many sustainable benefits, such as reduced water consumption, less land area for growth and good protein conversion. However, their use as food will be more difficult to normalize due to consumer perception.

Cellular agriculture being a new field, it is not well received by consumers, and in addition, further development of the products is required in order to achieve the best product, with essential nutrients and organoleptic characteristics similar to animal – based meat.

In conclusion, for a sustainable future, we should dramatically change both the food industry and our perception in regard with the food. Currently there are mainly two extremes, people that don't receive enough food and people that waste too much of it. With alternative food we could balance this difference and learn how to use food in a mindful way so we could preserve our planet.

REFERENCES

Abdulhafiz F., Mohammed A., Reduan M. F. H., Kari Z. A., Wei L. S., & Goh K. W., 2022. Plant cell culture technologies: A promising alternatives to produce high-value secondary metabolites. Arabian Journal of Chemistry.

Alae-Carew C., Green R., Stewart C., Cook B., Dangour A. D., & Scheelbeek P. F. D., 2022. The role of plant-based alternative foods in sustainable and healthy food systems: Consumption trends in the UK. Science of The Total Environment.

De Carvalho N. M., Madureira A. R., & Pintado M. E., 2020. The potential of insects as food sources – a review. Critical Reviews in Food Science and Nutrition.

Estell M., Hughes J., & Grafenauer S., 2021. Plant Protein and Plant-Based Meat Alternatives: Consumer and Nutrition Professional Attitudes and Perceptions. Sustainability.

Govorushko S., 2019. Global status of insects as food and feed source: A review. Trends in Food Science & Technology.

Hawkey K. J., Lopez-Viso C., Brameld J. M., Parr T., & Salter A. M., 2021. Insects: A Potential Source of Protein and Other Nutrients for Feed and Food. Annual Review of Animal Biosciences.

Lähteenmäki-Uutela A., Rahikainen M., Lonkila A., & Yang B., 2021. Alternative proteins and EU food law. Food Control.

Lehto E., Korhonen K., Muilu T., & Konttinen H., 2023. How do values relate to the consumption of meat and dairy products and their plant-based alternatives? Food Quality and Preference.

Madau F. A., Arru B., Furesi R., & Pulina P., 2020. Insect Farming for Feed and Food Production from a Circular Business Model Perspective. Sustainability.

Mattick C. S., Landis A. E., Allenby B. R., & Genovese N. J., 2015. Anticipatory Life Cycle Analysis of In Vitro Biomass Cultivation for Cultured Meat Production in the United States. Environmental Science & Technology.

Michel F., Hartmann C., & Siegrist M., 2021. Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. Food Quality and Preference.

Miyake Y., Tachikawa M., & Kohsaka R., 2023. Policy frameworks and regulations for the research and development of cell-based meats: Systematic literature review. Food Research International.

Motolinía-Alcántara E. A., Castillo-Araiza C. O., Rodríguez-Monroy M., Román-Guerrero A., & Cruz-Sosa F., 2021. Engineering Considerations to Produce Bioactive Compounds from Plant Cell Suspension Culture in Bioreactors. Plants.

Mouritsen O. G., Dawczynski C., Duelund L., Jahreis G., Vetter W., & Schröder M., 2013. On the human consumption of the red seaweed dulse Palmaria palmata L. Weber & Mohr. Journal of Applied Phycology.

Post M. J., Levenberg S., Kaplan D. L., Genovese N., Fu, J., Bryant C. J., Negowetti N., Verzijden K., & Moutsatsou P., 2020. Scientific, sustainability and regulatory challenges of cultured meat. Nature Food.

Rawiwan P., Peng Y., Paramayuda I. G. P. B., & Quek S. Y., 2022. Red seaweed: A promising alternative protein source for global food sustainability. Trends in Food Science & Technology.

Rischer H., Szilvay G. R., & Oksman-Caldentey K.-M., 2020. Cellular agriculture—Industrial biotechnology for food and materials. Current Opinion in Biotechnology.

Rolland N. C. M., Markus C. R., & Post M. J., 2020. The effect of information content on acceptance of cultured meat in a tasting context. PLOS ONE.

Rubio N. R., Xiang N., & Kaplan D. L., 2020. Plant-based and cell-based approaches to meat production. Nature Communications.

Siddiqui S. A., Bahmid N. A., Karim I., Mehany T., Gvozdenko A. A., Blinov A. V., Nagdalian A. A., Arsyad M., & Lorenzo J. M., 2022. Cultured meat: Processing, packaging, shelf life, and consumer acceptance. LWT.

Tuomisto H. L., & Teixeira de Mattos M. J., 2011. Environmental Impacts of Cultured Meat Production. Environmental Science & Technology.

Tumisto H. L., 2019. The eco-friendly burger. Science & Society.

van Huis A. 2021. Prospects of insects as food and feed. Organic Agriculture.

Wang Y., Lyu B., Fu H., Li J., Ji L., Gong H., Zhang R., Liu J., & Yu H., 2023. The development process of plant-based meat alternatives: Raw material formulations and processing strategies. Food Research International.

Wendin K. M., & Nyberg M. E., 2021. Factors influencing consumer perception and acceptability of insect-based foods. Current Opinion in Food Science.

https://gfi.org/resource/year-in-review-2021/ accessed on 19th March 2023

https://ianr.unl.edu accessed on 24 th March 2022.