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Disagreements in cloning for business purposes

Desacuerdos en la clonación con fines comerciales

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Abstract

This article is a review of modification of somatic cells by nucleus transfer for multiplication mostly known as cloning, regarding ethics, governance, implications, and business usages of cloning. The article raises questions to researchers, as well as ethical and sociological considerations of current practices, through article reviews and case analysis.

Key words: Cloning, ethics, business, sustainability.

Resumen

Este artículo es una revisión sobre la modificación de células somáticas por transferencia de núcleo para multiplicación más conocida como clonación, con respecto a la ética, la gobernanza, las implicaciones y los usos comerciales de la clonación. El artículo plantea interrogantes a los investigadores, así como consideraciones éticas y sociológicas de las prácticas actuales, a través de revisiones de artículos y análisis de casos.

Palabras clave: Clonación, ética, empresa, sostenibilidad.

1. Introduction

In the next one hundred years, about half of Earth's species could have been disappeared. In fact, the human activities of the past two centuries might have had the severest impact on mass extinction of all time (De Salle, Amato, 2004. Several factors lead to this extinction crisis, like aquaculture, agriculture, climate change, deforestation, and unchecked animal trade. (West, 1988).

Therefore, the conservation discipline becomes even more important. Conservation biology can be understood as crisis discipline and has therefore incorporated many technologies to increase the accuracy of conservation decision-making (De Salle & Amato, 2004). One of them is the cloning practice, which becomes more and more popular among scientists and which is hoped to renew Earth's lost and fading species. (West, 1988). Cloning means the artificial conception of a genetically identical individual through Somatic Cell Nuclear Transfer (SCNT). The genetic information is thereby not manipulated but copied. By means of cloning of animals, mostly reproductive aims are being pursued (Camenzind, 2010).

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As the possibility of cloning becomes more and more possible through innovations in the technology, the discussion around this topic shifts from “could we?” to “should we?”. Ethical questions arise, where possible harmful consequences are considered (IUCN, 2016). The Cambridge dictionary defines biodiversity as “the number and types of plants and animals that exist in a particular area or in the world generally, or the problem of protecting this”, by the optics of this definition, cloning could increase the number of individuals.

This paper aims to analyze the modification of somatic cells by nucleus transfer for multiplication, also known as cloning, with a literature review on governance (policy and ethics), scientific view, cases, and possible business applications. Other aspects of genetic manipulation (e.g. cellular modification, Genetically Modified Organisms (GMO’s), plant cloning) were not discussed in this research. Although one can derive from the other, it was focused on the specifics of cloning.

1.1. Cloning historical background

Dolly, the likely most famous cloned animal, was, according to Wilmut et al. (1997) the result of a single nucleus transferred to an enucleated cell, providing successive divisions until the offspring. One of the main points of the research (ibidem) was the possibility of nucleic transfer between different aged individuals, that means, the aging difference between the two animals, did not cause irreversible modification of the restricted nucleic genetic material that is necessary for development of the molecular divisions, actually the cytoplasm showed chemical reactions of the genes, meaning that it’s possible to create a clone from a much older individual.

Dolly was a twin born six years later than it sibling. It rose awareness all over the globe about the possibility of cloning, with prompt reply in policy creation, with prohibitive measures in USA being drawn right after the publication of the paper, also with European countries and China prohibiting human cloning (Kolata, 1998).

Silver (1997), a molecular biology professor, wrote a thought-provoking book after Dolly’s cloning, in which it gave a hypothetical example where a girl was cloned in the hope that her sister-clone would have a histocompatibility marrow to save her from leukemia. So, in this book he discussed the possibility of human cloning for saving lives.

Although the sheep Dolly seems the most prominent case in cloning. According to the Genetic Science Learning Center of the University of Utah (2017), its history goes back to 1885 when Hans Dreisch showed that by shaking a two-cell~~s~~ embryo of a sea urchin, it would separate it cells and generate two sea urchins, showing for the first time that each cell holds a complete set of genetic information.

The method of physically separating two-cells embryos as a cloning experiment was also done in 1902 by Hans Spemann, this time with salamanders and dividing the embryo with a baby’s hair, with the same methodology, in 1928 he discovered that the nucleus holds all the genetic information.

Nuclear transfer, as what we know as cloning today, happened for the first time in 1952. Briggs and King (1952) transferred the nucleus of an embryo to an enucleated frog egg, creating a clone, they also saw that the nucleus from more developed embryos had a lower success rate, which reinforced the findings of Spemann about cellular division in advanced stages of the embryo.

Cloning history only develops with scientific improvements, up to Dolly, where it starts an uprising in cloning. In 2001 started the cloning of endangered species - with the thought of promoting biodiversity, reaching in 2009 a clone of an extinct species - the Bucardo – which ended up dying right after birth due to a lung problem (Genetic Science Learning Center of The University of Utah, 2017).

2. Science of cloning

The term cloning refers to different practices that generates an identical copy of a living organism (National Human Genome Institute (NHGI), 2017), that can also occur naturally, like in identical twins. According to the NHGI (2017) for artificial cloning there are three types:

a) Gene cloning: Copies of parts (segments or genes) of the DNA;
b) Reproductive cloning;
c) Therapeutic cloning.

For b and c, many of the techniques are shared, but with different usage. For b it's to produce a whole living organism and c producing embryonic stem cells for recreating tissues (ibidem).

For artificial reproductive cloning there are different techniques that can be used, such as (Learn Genetics - University of Utah, 2017):

a) Artificial Embryo Cloning: mimics the natural process of generating identical twins, like the experiments both Dreisch and Spemann did, as explained on chapter 1.1.
b) Somatic cell nuclear transfer: this was the technique used to clone the Dolly sheep, it allows for reproducing a living being after a temporal lapse. Where it's taken the nucleus of a somatic cell (a cell other than a reproductive cell (e.g. sperm)), because in mammals this contains the complete set of chromosomes. After taking the nucleus of a somatic cell, it is transferred to an enucleated egg cell, passing through chemical processes this cell behaves as a regular embryo. Then to be inserted and fertilized in a uterus (in mammals case). For only a few clones, there are hundreds of embryos and attempted pregnancies needed. Generally, researchers fuse the DNA of an endangered species with eggs from a closely related species, which is also used as a mother, a so-called surrogate mother. This is due to the scientist's poor understanding of endangered animals' reproductive physiology, which makes it too risky to extract a sufficient number of eggs from the endangered species (Jabr, 2013).

This research focuses on reproductive cloning of endangered species, with also regarding to food and other possible uses of cloning of animals. Since the SCNT also allows for cloning living beings of different ages, since it requires a somatic cell, that can even come from a dead animal.

Also, SCNT gives more room to replicate species that are endangered or extinct, since only requires a nucleus from a non-reproductive cell and a female reproductive cell without its nucleus. Even when considering the uterus for the conception of the specie, it may be possible for the usage of foster mothers from similar species.

2.1. Disagreements in the application of cloning technologies – should we?

The ability to clone is not questioned anymore, the technology exists. Thus, the conversations focus more on the ethical and moral concerns of the implementation of cloning. Cloning for saving endangered species is a controversially discussed topic, where some scientists are in favor of the procedure, while others' view is more skeptical (Lee, 2001).

Some scientists are optimistic about the possibility that cloning could help to save endangered species, especially when there are only a few dozen of these animals left and they are positive, that clones could increase the genetic diversity of an endangered population (e.g. Vrijenhoek, 1994, Ryder, 2002). Though this is only possible if researchers have access to preserved somatic cells from those species.

The development and improvement of new techniques of cloning, pointing to recent successes of cloning wild mammals using closely related domestic species, could help save endangered species and/or stabilize a shrinking population. Some claim that a genetically homogenous but stable population would still be better than extinction (Lee, 2001).

Therefore, it's suggested continuing to collect and preserve the genetic information of endangered species of the tissues on ice and keeping them in so-called "frozen zoos". In the hope that in the future, when the technique has improved, the DNA would already be there. (Jabr, 2013, West, 1988, Lee, 2001). Also, it is argued that cloning techniques of endangered species may be a possible choice to maintain animals in captivity in poor countries, without sufficient resources for conservation (Lanza et al, 2000).

On the other hand, many researchers express their concerns about cloning for conservation efforts. One important critique is that cloning could become more important than other conservation efforts. Instead of fighting the initial reasons of why animals become endangered in the first place, like hunting and habitat destruction, they fear that funds, which would go into habitat preservation, may divert away (Lee, 2001).

Critics also see a decline in the genetic variety within a species when cloning, which could bring possible emergence of inheritable anomalies and diseases through cloning (Camenzind, 2010). Furthermore, scientists are critical of the present technology of cloning, which they say is too ineffective to make much of a difference. The average success rate is of less than five percent, concerning wild animals even less than one percent (Jabr, 2013), therefore a large effort needs to be made, for a small chance of success.

The low success rate is mostly because clones are not exact replicas of their counterparts, by a procedure of injecting the DNA of one species into the egg of another one creates an unusual hybrid embryo, where often surrogate mothers from a related domestic species are being used to carry out the offspring. The problem is that the embryo often fails to develop properly in the womb of its surrogate mother (Jabr, 2013). Therefore, clones have problems in developing abnormalities and premature aging, which leads to suffering and short lives (IUCN, 2016). Therefore, now, cloning is neither feasible nor an effective conservation strategy (Jabr, 2013).

3. Governance overview in cloning

Regulation of animal cloning is not well developed in a worldwide context, but they fall broadly into two categories: the regulation of animal welfare and the regulation of foods derived from cloned animals (Bruce et al., 2005). Most laws apply to animals used in agriculture with the main focus on the food and less on the safety of the animals (West, 1988).

The policy structure is also divided into the direct regulations in cloning (e.g. COM/2013/0892 - European Parliament and the Council proposal on cloning of animals for farming procare), which does not apply to the cloning of endangered species, and into indirect regulations in cloning, like regulation for biodiversity protection and/or genetic manipulation that may direct or indirect affect cloning (e.g. 16 U.S.C. Section 1536(a)(2) of the USA Endangered Species Act (ESA)).

The regulation of Animal welfare takes ethical considerations into account through a cost-benefit analysis of the harm to the animal versus the benefit to humans (West, 1988). Therefore, this chapter also discusses ethics regarding cloning, since ethic codes are a form of non-legislative regulation that constrain actions of some parts (Sossin & Smith, 2003).

3.1. Direct cloning regulations

Direct policies in cloning usually refer to cloning for farming and food purposes which goes beyond the scope of this analysis, and because human wellbeing is the main concern for legislators.

On an international level, the Cartagena Protocol on Biosafety, adopted in January 2000 was negotiated under the auspices of the Convention on Biological Diversity and entered into force on 11 September 2003. It provides rules for the safe transfer, handling, and use of “living modified organisms” (LMOs). The Protocol aims at addressing the threats LMOs pose to biological diversity and possibly to human health. Animal cloning does not appear to fall within the scope of the Cartagena Protocol, since a cloned animal does not fit the definition of an LMO.

On the European level, an EU proposal (COM/2013/0892) might be introduced to organize the cloning of bovine, porcine, ovine, caprine, and equine species that are kept and reproduced for farming processes (European Union Law, 2013). The aim of these laws in the European Union is to try at least a preliminary approval of the agriculture industry involved in animals’ treatment and cloning (Westhusin & Young, 2016).

After consultation with different stakeholders this regulating proposal prohibits the cloning of animals for food purposes and for marketing live animals, this means trading cattle, for example. It ensures that cloning is not used - as examples given in chapter 4 - for cloning high valued cattle for trading purposes which could diminish the genetic variability of the specie if implemented in a large scale. Especially when considering the financial returns of such practice, an original elite Holstein bull has a market price between USD 250,000-1,000,000, and cloning this bull has a cost of around USD 100,000 (Reuters, 2001).

Contrary to the EU proposal, the United States Food and Drug Administration (FDA) (FDA, 2018) considers that animal products derived from clones are safe for human consumption, according to their research and expert reviews. It is also important to notice that the FDA ruling on the matter also allows for livestock generated by clones to be commercialized.

3.2. Indirect cloning regulations

There are regulations regarding endangered species protection, where the cloning them, may be seen as risky for introducing animals sharing the same genetic material inside a group, that might in the long term cause problems due to the low genetic variability. Like the case presented by the ESA in USA (16 U.S.C. Section 1536(a)(2)), where cloning may pose a risk for the biodiversity due to the loss of genetic material by having livestock born from cloning and the implications of large-scale cloning (Bruce et al., 2005).

The ESA in the USA, more precisely 16 U.S.C. Section 1536(a)(2) (Endangered Species Act, 2000, p.1), says that agencies cannot authorize or fund activities that are: “not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species”, and to some extent cloning can threaten species, by diminishing the genetic modification within the population. Also cloning for protecting biodiversity can generate a misdirection of funds, where it would be focused mostly on cloning instead of other mitigation strategies (considering that financial funds are limited) (DeSalle & Amato, 2004)

Regulations dealing with GMOs and LMOs are usually ambiguous in their understanding and their applications for cloning purposes (Bruce et al., 2005). For both, regulations are usually regarding food purposes, where also USA and EU have contradictory points of view, but using the same base of scientific research (Lau, 2015). Although animal cloning has not yet been regulated as such at an EU level, it is doubted under the relevant EU Directives if animal clones should be considered genetically modified organisms, therefore GM regulation is unlikely to apply to cloned animals in EU (Bruce et al., 2005).

Animal cloning in its experimental stage is regulated through animal experimentation laws, while animal cloning as an applied science remains unregulated. There exists no EU-wide legislation regarding the cloning of animals for commercial purpose. Thus, the regulatory frameworks of member states need to be taken into consideration (Bruce et al., 2005).

Currently, the application of cloning of animals is regulated by the animal welfare regulation. To apply the technology of cloning, a license is needed. Due to the possible suffering of the animals and the insecurity, cloning offends the animal welfare rights and would not be compatible with the law (Camenzind, 2010).

3.3. Animal welfare

Standards for clear assessment of animal welfare are not well developed so there is some uncertainty as to how the welfare regulation might affect the use of cloned farm animals (Bruce et al., 2005).

In Europe, the Treaty of Lisbon (European Union, 2007) states that, animals are sentient beings. Additionally, specific directives are addressed at the protection of individual animals. In terms of animal used for experimental and other scientific purposes, a more recent statement in EU legislation can be found in Article 12 of Directive 2010/63 (European Parliament, 2010, p.1):

> *"On the protection of animals used for scientific purposes". "Animals have an intrinsic value which must be respected. There are also the ethical concerns of the general public as regards the use of animals in procedures. Therefore, animals should always be treated as sentient creatures and their use in procedures should be restricted to areas which may ultimately benefit human or animal health, or the environment. The use of animals for scientific or educational purposes should therefore only be considered where a non-animal alternative is unavailable. Use of animals for scientific procedures in other areas under the competence of the Union should be prohibited."*

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4. Ethical considerations in the application of cloning

Cloning is a controversial subject, where it seems to be important to not only include scientific facts but also to raise ethical questions. There are various ethical positions, each of which tackles cloning in a different way. This paper focuses on three different directions in ethics; Anthropocentrism, Pathocentrism, and Physiocentrism.

4.1. Anthropocentrism

The prevalent position today is the anthropocentric orientation. It is the most human-centered approach, where the world is being seen only from the perspective of the human being. Thus, the environment will be protected only so far, as it is useful for human beings. Our responsibilities to the ecosystems are only in place to protect the Earth for human survival. This means that only the part of nature that is useful to humans will be protected. Therefore, only our own interests motivate the protection of the environment (Brenner, 2008).

Anthropocentrism is differentiated into strong and weak forms. The strong anthropocentrism, which is barely represented, attributes a moral status only to human beings. The weak form acknowledges a moral status to animals and plants, but if there is an interesting conflict, human interests overweight those of animals and plants. The approach recognizes that there is a value in nature but it puts human interest first. This exceptional position of the human being is justified through his equivalence with God and his ability to be reasonable (e.g. Camenzind, 2010, Brenner, 2008).

From an anthropocentric point of view, concerning the application for cloning endangered animals, there wouldn't be any ethical restrictions. The cloning of endangered animals is seen as valuable for human beings, to secure biodiversity also in the future, disregarding the drawbacks for the cloned animals. But then the question could be raised, from an anthropocentric perspective, why would it be important to have this diversity? For what is it useful? How new business models could be created from cloning?

4.2. Pathocentrism

The position of pathocentrism criticizes the position of anthropocentrism, because it only takes the ability for reasoning into account, for an individual to have a moral status. Pathocentrism views the group as moral regarded beings, it considers not only the capacity of reasoning, but all individuals that can feel pain and are able to suffer, therefore not only human beings are considered as moral beings, but all individuals that can feel pain. “Pain is pain, no matter what the species of the being who feels it“ (apud. Camenzind, 2010, pp. 23) or as Jeremy Bentham (1748-1832) quotes: “The question is not, Can they reason? Nor, Can they talk? But, Can they suffer?” (apud. Brenner, 2008 pp. 125) For Bentham and Singer, both utilitarian, moral action refers to the aim of utility maximization.

The benefit in the classic utilitarismus of Bentham is described as lust, in Singer’s “preference utilitarianism”, as the satisfaction of needs. The best action is the one, which brings the most satisfaction to interests. To be able to experience lust or to have interests, sentience is required, whereby animals are included (Wolf & Tuider, 2014). Indicators for pain and suffering exist in animals, such as the behavior of shivering, howling and moaning, tension, etc. and concerning physiology widened pupils, increased blood pressure, and a faster pulse frequency can also be seen as pain and suffering indicators.

Besides illnesses and injuries, also a lack of nutrition, lack of water, lack of movement, isolation or a too great social density can be a reason for suffering (Camenzind, 2010). The question remains, how far this position goes. It is obvious that it includes animals, but it does not determine if all animals are considered or only selected examples, and if plants are part of it as well (Brenner, 2008).

About the application of cloning of animals, two main issues need to be considered: Do the animal feel pain or suffer through cloning? And are any of their interests constrained? Referring to the first question, if the process of cloning will generate suffering it is ethically illegitimate. In theory, cloning does not necessarily generate pain, but in the actual practice, this is unfortunately often reality. It can generate stress and pain in the donated animals, the surrogate mothers, or the clones themselves. It can lead to excess fetal size, abnormal placental development, enlarged internal organs, sudden death, reluctance to suckle and difficulty in breathing and standing, defective immune system, and infectious diseases. It can be concluded that, according to the current practice, cloning can cause suffering, which argues against the application of cloning. In the cases where it doesn’t cause pain, this position does not criticize cloning and focuses more on the way, how animals are being kept (e.g. in captivity, close monitored) (Camenzind, 2010). In the second question, this paper focuses on the culture of animals. Cultures can be described as: those group-typical behavior patterns shared by members of a community that relies on socially learned and transmitted information (Laland & Hoppitt, 2003). In the behavior and adaptation of animals, it is not only the individual animal experience that is important but also learning from others, and cultural conformity to the group. Hereby the way of behavior is not only developed evolutionary but also through learning (Van de Waal et al., 2013) as researchers have found that cultural transmission takes place in animals, including fish, insects, meerkats, birds, monkeys, and apes (Balter, 2013).

It can be distinguished between two different ways of cultural learning: Imitation and teaching. An example of teaching would be the killer-whale-mothers, that show their calves how to hunt seals through the controlled technique of running (Kendal, 2008). At the 11th meeting of the UN Conference on the Protection of Migrating Wild Animals (CMS), the culture of whales and dolphins was classified as a protected area in a resolution. "The conference recognizes that some social mammals, such as several species of cetacea, apes, and elephants, have signs of non-human culture," the document says. When animal populations die out, not only individuals but also cultures are lost. The resolution calls on the participating countries and organizations to include the culture of species in their conservation efforts. The CMS now wants to create a list of the culture-creating animals (UNEP, 2014).

Referring to cloned mammals (and birds, and some reptilian species with maternal behavior), with a surrogate mother from other species, it may have real problems adapting to their native habitat (Ehrenfeld, 2006) How would those animals be integrated in nature and learning their behavior? Some might argue that foster families from similar species could play the role, but this wouldn't teach specifics of the species culture. Thus, under the pathocentrism optcs it is concluded that against the application of cloning of endangered species.

4.3. Physiocentrism

In the approach of physiocentrism, a being or an ecosystem is considered as a moral being not only when it is able to suffer and feel pain, but there are also other criteria that count (e.g. intrinsic value). Therefore, not only the criterion of suffering is taken into account, but also interventions in the appearance, humiliation, and exploitation. Creatures with an intrinsic value also possess an inherent dignity (Camenzind, 2010).

Exists "justified" and "unjustified" disregard for the dignity of a being, depending on the interests of human beings. If the interests of human beings overweight the animal interests, then a disrespect for the dignity of the creature would be justified. Thus, there must be done a weighing of competing interests, between the beneficiary interests of humans (e.g. health, quality of life, economies, protection of the environment, biodiversity, gain of knowledge, competitiveness, and so on and the interest of the animal is being protected. If the human interest outweighs the dignity of the creature is respected (Camenzind, 2010).

In terms of species conservation interests of esthetic and environmental protection confront the well-being and burden of the cloned animals. The dignity of a cloned animal can be preserved, if their specific traits and culture are taken into account (Brenner, 2008).

5. Cloning endangered species: real examples

In 2001 a group of European researchers (Loi et al., 2001.) published a paper about their cloning of a Mouflon (Ovis orientalis musimon), a specie of a wild sheep which is in risk of extinction, using the ovary cells (oocytes) of a close related domesticated specie.

The nuclear donor of those cells were dead animals, which may imply the possibility of cloning already extinct species, as long as there is a close related animal. This means that the cloning of dead animals is a real possibility and the constraint would be the low success rate of cloning (1-2% of embryos becomes viable offspring).

Loi et al. (2013), points out that, although possible to clone, the finding of a close related specie to be a foster mother, for the cloning process could be a major problem. Given the low success rates there are researches on how to optimize and increase success rate, and the optimal use of foster mothers (e.g. Wakai et al., 2013).

Although biologically viable there are both ethical and economical constraints in large scale cloning experiments in order to save endangered species. For ethical and even biological order one might discuss the genetic variability of cloned introduced species and for the economic perspective the cost of a highly specialized staff and instruments to realize the procedures.

In Brazil, EMBRAPA (Brazilian governmental agency related to farming research) is considering cloning (along with artificial insemination and in vitro fertilization) for increasing the population of animals in risk of extinction (Paes, 2009), the agency reserved cells from dead animals in the Brasília zoo and plan on using roadkill. (ibidem)

Cloning could also save fisheries, most of fishes are endangered or in risk of extinction due to overconsumption and overfishing. Through cloning and genetic modification, fishes could increase their growth rate in captivity and being more resistant to diseases (West, 2006).

Also, West (2006) points out another usage for cloning of, not endangered, but rare animals, such as competition horses, or male bovines whose characteristics make their semen sells at a higher price. This might create a market for cloning of “special” individuals of a specie, leading - if lead to an extreme - to a decrease in intraspecies variability or the creation of genetic doping for example.

5.1. Cases analysis

There are many applications, as a value proposition, for the utilization of cloning in different industries, such as food and agriculture, healthcare and medical, tourism, and cosmetics. Cloning applications can be used on a vast array of animals, to produce the desired genotypes, such as award animals or near to extinction (Westhusin et al., 2001). Therefore, the applications for more efficient natural inputs attributions (e.g. larger animals, fruits with certain characteristics, or even endangered species) can be a competitive advantage in several markets.

Even though cloning can increase the nominal number of living beings of a certain species, it decreases biodiversity in the sense of repeating genetic material, which may lead to a weakening of the specie in the long run - if thinking of mass use of cloning for saving endangered species. Wright (2018), assumes there will be cloned animals for hunting in 2070, and that cloning extinct animals could become a value proposition to increase the attractiveness of zoos. Vertebrate animal cloning is likely to remain a part of zoo-based programs in assisted reproduction (Ehrenfeld, 2006)

If further increase in technology is shown possible, and without further costs, and at the same time frame of cloning through SCNT, but adding a step of doing genetic modification to increase the diversification, the technique may be beneficial for increasing the number of living organisms in a certain species, with genetic variability, but the implications for the ecosystem balance need further studies.

One has to consider that cloning can be used not only for large, macro-species but as well it can be used in enzymes, bacteria, fungus, etc. which can be used in industrial processes in food, pharmaceutical, and other industries, if synthesized in large scale, through cloning. In the food industry, enzymes have a vast array of applications, from bread, dairy, wine, to fish and juice extraction, between many. Also, enzymes are being used for vaccines, for antigens delivery in oral covid-19 vaccines, for example (Kaur & Gupta, 2020).

One example of cloning possibility in the food industry is transglutaminase, an enzyme forming bonds of isopeptides between proteins through catalysis (Kieliszek & Misiewicz, 2013), which means being able to put together different parts of meats into one piece. Transglutaminase is an expensive process, and there are attempts of finding the microbial origin of this enzyme (Zhu & Tramper, 2008). As cloning of transglutaminase is possible (e.g. Washizu et al., 1994, Duran et al, 1998, Lin et al., 2004) it could turn to be a viable opportunity.

Other examples in the food industry could be the cloning of Lactococcus lactis, a bacterium used in cheese and dairy production, or cloning Rhizomucor miehei, which is a fungal glycogen breaching enzyme, that can increase bread volume by 26% and increase shelf life when compared to non-treated bread (Wu et al., 2014).

On the medical industry, another example would be cloning for organ harvesting. Iran has legalized the sale of organs and there is no waiting list for kidney transplant in Iran (Ghods & Savaj, 2006), would cloning for organ harvesting become an acceptable practice?

6. Conclusion

The technology for cloning endangered species is possible with current technology, although with a low success rate and the difficulty of finding foster mothers, so-called surrogate mothers.

In the literal sense of the word "biodiversity", cloning endangered species increases the biodiversity because it increases the number of species in a region. But, with the current technology cloning reduces (the possibility) of genetic variability, because a cloned animal has the same genes, it's a "copy".

Cloning not only poses a risk for the species being cloned, with a few threats to the environment, given the population increase and the threat for the ecosystem equilibrium. One might argue that cloning should never be used as a conservation strategy, because of its limited capabilities and decrease in genetic variability within a specie. Furthermore, cloning might create a false impression for the public by offering an easy way to save biodiversity and reduce awareness of protection of species and their habitats.

This may even create an illusion where all other environmental-related problems could be solved by technology. Several species are endangered, often due to the destruction of their habitats, and this cannot be ignored by the general public, which needs to increase awareness of global conservation strategies. The possibility of introducing endangered species in controlled environments, where it lack a natural habitat, like introducing into a Zoo.

Going on a micro-level, enzymes are a less tangible part of the food to the final users, the implications of enzyme cloning in food marketing could be minimal, as with GMO's perception and risk depends on the individual's level of knowledge (Klerck and Sweeney., 2007). Most consumers might fail to understand the purpose of those enzymes and where were they used in the production process; therefore, the large impact would remain in tangible food items such as fruits, vegetables, or meat.

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