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An ecofeminist perspective on new food technologies

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Abstract

New food technologies are touted by some to be an indispensable part of the toolkit when it comes to feeding a growing population, especially when factoring in the growing appetite for animal products. To this end, technologies like genetically engineered (GE) animals and *in vitro* meat are currently in various stages of research and development, with proponents claiming a myriad of justificatory benefits. However, it is important to consider not only the technical attributes and promissory possibilities of these technologies, but also the worldviews that are being imported in turn, as well as the unanticipated social and environmental consequences that could result. In addition to critiquing dominant paradigms, the inclusive, intersectional ecofeminist perspective presented here offers a different way of thinking about new food technologies, with the aim of exposing inherent biases, rejecting a view of institutions like science and law as being objective, and advancing methods and rationales for a more explicitly ethical form of decision-making. Alternative and marginalized perspectives are especially valuable in this context, because careful reflection on the range of concerns implicated by new food technologies is necessary in order to better evaluate whether or not they can contribute to the building of a more sustainable and just food system for all.

Keywords: ecofeminism, biotechnology, in vitro meat, GE animals, novel foods

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Introduction

In light of intensifying ecological pressures, an increasingly volatile climate system, existing problems of hunger and malnutrition, and a burgeoning appetite for animal products, scientific and technological innovations are touted by some as being valuable tools in developing sustainable strategies for feeding a growing global population.[1] To this end, new food technologies[2] like genetically engineered (GE) animals[3] and *in vitro* meat (IVM)[4] are in various stages of research and development. With the biotechnology industry eager to introduce their wares to the market, the availability of these types of products is only expected to grow in coming years. No longer constrained to the realm of science fiction, food that has effectively been grown in labs is well on its way to becoming a commercial reality.

Proponents claim a variety of justificatory benefits for the food products of animal biotechnology, including that that they could cut hunger, offer public health benefits, mitigate the environmental impacts of conventional flesh food production, and improve animal welfare (Dilworth & McGregor, 2015; Hopkins & Dacey, 2008; Hume, Whitelaw & Archibald, 2011). However, for each benefit raised, others have pointed to corresponding concerns (Dilworth & McGregor, 2015; National Research Council (NRC), 2002, pp. 6-14), including general doubts about whether agricultural technologies can live up to their grand promises (Hakim, 2016; Shiva, 2000). Meanwhile, as existing debates about genetically modified organisms (GMOs) illustrate, there is demonstrable public unease surrounding some of these latest techno-scientific interventions (Frewer et al., 2004). Although there is a substantial body of literature on genetically modified (GM) crops, emerging research reveals that the public perceives modified crops and modified animals differently (Vàzquez-Salat & Houdebine, 2013; Vàzquez-Salat, Salter, Smets, & Houdebine, 2012), indicating that there is something about animal biotechnologies for food production that triggers trepidations beyond those which have already been debated in the context of plants.

In addition to the obvious import of cultural and social factors to food studies, law, science, and technology are also significant because of the ways in which they directly and indirectly mediate the options available and unavailable in deciding what, how, and why to eat the way we do. Accordingly, in the context of food, the tensions between new and emerging technologies, societal perceptions, scientific assessments, and the law and policy-making that occurs at the nexus of these competing concerns provides fertile grounds for study. As a legal

[1] Recent projections estimate that the global population will swell to 8.5 billion by 2030, 9.7 billion by 2050, and 11.2 billion by 2100 (United Nations, Department of Economic and Social Affairs, Population Division, 2015, p. 2).
[2] More precisely, these are food products derived from animal biotechnologies. However, for ease of reference, they are referred to as "new food technologies" here, to capture the novelty of these technological applications when it comes to food.
[3] GE animals are animals whose genomes have been modified through the process of transgenesis. There is a range of applications for which GE animals have been developed, with human consumption being only one of them. For more information, see Jaenisch (1988).
[4] Also referred to as lab-grown meat, cultured meat, test-tube meat, vegetarian meat, and shmeat, among other names.

scholar, I am, of course, interested in the ways in which food technologies are formally defined and regulated, especially since regulatory systems have been identified as being "among the most important influences in determining the course of technological innovation" (Bonny, Gardner, Pethick & Hocquette, 2015, p. 258). However, more broadly, I am also interested in the ways in which food (and flesh food especially (Adams, 1990)) plays a profoundly semiotic and discursive role, and is often deeply tied to political, economic, and social power (Counihan, 1998, pp. 2-5).

Feminist thinkers—who have long been proponents of critical analysis in myriad domains—have not been silent on the gendered dimensions of food production and consumption (Allen & Sachs, 2007; Avakian & Haver, 2005; Kimura, 2013). According to the Food and Agriculture Organization of the United Nations (FAO), women produce more than half the world's food, and the scope and scale of women's influence on food security at all levels is undeniable (FAO, 1999, 2016a). Feminists have also drawn attention to the ways in which the institutions and practices of science (Harding, 1986), technology (Faulkner, 2001), and law (Smart, 1992) are distinctly gendered. Although these lines of argument are not new, they have not yet been applied specifically to some of the newest and emerging food technologies, a task that I endeavour to undertake here.

Rather than raising solely ecological or social concerns, animal biotechnologies for food production implicate a vast swath of current issues, including "[t]he global crises of climate justice, food security, energy justice, vanishing wildlife, maldevelopment, habitat loss, industrial animal food production, and more" (Gaard, 2011, p. 32). Inevitably, such diverse issues are important to a broad spectrum of stakeholders, including those who have typically been marginalized, such as women, animals, and Nature. Thus, an inclusive perspective like ecofeminism that views "all of the various forms of oppression as central to an understanding of particular institutions" (Gaard & Gruen, 1993, p. 29) can illuminate the impacts of new food technologies as they affect a range of different concerns and groups. Although an ecofeminist interrogation of the political, social, and ethical dimensions of new food technologies may be imperfect, it is arguably a necessary corrective for some of the most damaging facets of a more uncritical approach, including the narrow grounds on which the benefits and impacts of technologies are assessed under a purportedly more "science-based" approach.

To provide some more context, Part 1 introduces two specific new food technologies, and reviews the way they are currently defined and regulated in Canada. Part 2 provides a basic overview of ecofeminism and its relevance to this topic as a perspective that challenges the ontological, epistemological, and ethical underpinnings of currently prevailing paradigms. Part 3 goes on to apply ecofeminist principles to new food technologies across four domains: institutional, environmental, socio-economic, and animal. The ultimate aim of my analysis is not to undermine the real and potential benefits that science and technology have enabled, but rather, to draw attention to the fact that technological artifacts can "embody specific forms of power and authority" (Winner, 1980, p. 121) and consider the implications of this notion when applied to food. Part 4 concludes by emphasizing that my goal is not to condemn, but to widen the

dialogue, challenge embedded assumptions, and seek a deeper understanding of what is signalled by the vast transformations enabled by technology in the social, political, and ethical structures of our world.

Novel foods and their regulation

The application of science and technology to the realm of food production is not in itself new, but by and large, animal biotechnology for food production is a hitherto unchartered area. In recent years, notable advances have been made with both GE animal and IVM technology in terms of their development and their movement through the regulatory process, bringing them closer to market than ever. Indeed, Health Canada and the Canadian Food Inspection Agency (CFIA) recently approved the sale of the AquAdvantage salmon (AAS) for human consumption (Health Canada, 2016a), as did the Food and Drug Administration in the United States (US) (Food and Drug Administration, 2015), giving it the distinction of being the first GE animal sanctioned for this purpose.

A transgenic fish produced by the Massachusetts-based AquaBounty Technologies Inc. (AquaBounty), the AAS is the product of combining a growth hormone gene from the Chinook salmon and regulatory sequences of an antifreeze protein gene from the ocean pout with the genome of an Atlantic salmon. The result is a fish that is able to grow faster and year-round, thereby reaching market size much sooner than its unmodified counterpart. Despite being granted the formal stamp of approval, there has been vocal opposition to the AAS by numerous environmental and food safety groups, including in the form of legal challenges brought against the regulators (Ecology Action Centre). However, at present, AquaBounty officially has the green light to sell and market the AAS in Canada, and the AAS has already appeared on supermarket shelves (Yarr, 2017). Since Health Canada did not identify any health and safety concerns in the course of its review, there are no special labelling requirements for the AAS (Health Canada, 2016a).

Meanwhile, several scientists and start-ups around the world are currently working on making a large-scale IVM production system a commercial reality. IVM is derived from a tissue engineering process that involves growing muscle tissue using starter stem cells from live animals, which are put into a culture medium where they proliferate with the help of a bioreactor, eventually becoming an edible flesh food.[5] The first burger grown from stem cells was presented at a press conference in London in August 2013, with some commentators noting that this event marked not only a milestone in the development of the scientific and technological capability to produce IVM, but also serving as proof of concept (Mattick & Allenby, 2013, p. 64). Although there remain several major practical barriers to deploying IVM technology as an alternative to conventional industrial meat production systems—and despite sustained and ongoing public

[5] For more detailed discussion of the process, see Sharma, Thind & Kaur (2015).

debates about the associated environmental, health, social, and ethical concerns—scientists and entrepreneurs have showed no signs of slowing down their progress in this area.

The approach to regulating new food technologies is country-specific. In Canadian law, the products of these technologies are currently defined and regulated as "novel foods".[6] The existing regulatory framework governing public health, food safety, and nutrition, broadly speaking, falls under the shared federal mandate of Health Canada and the CFIA. Generally, Health Canada establishes standards and policies governing the safety and nutritional quality of foods and develops labelling policies related to health and nutrition, while the CFIA develops standards related to the packaging, labelling, and advertising of foods, as well as handling inspection and enforcement duties (Health Canada, 2006). Additional departments, such as Environment and Climate Change Canada and Fisheries and Oceans Canada, may also be involved, depending on the characteristics of the product in question.

Given the newness of animal biotechnologies for food production, the actual rules and processes governing their development, production, selling, and marketing are emerging in something of a piecemeal, ad hoc manner. Prior to sale, manufacturers or importers of novel foods are required to submit information to Health Canada regarding the product in question in order for a determination to be made regarding the product's safety, with the evaluation being broken down into nutritional, toxicological, allergenic, and chemical considerations (Health Canada, 2006). Notably, consideration of environmental impacts or indirect human health aspects of the manufacture or import of novel foods remains a gap in the assessment of novel foods under the *Food and Drugs Act and Regulation*, and is instead dealt with under the *Canadian Environmental Protection Act, 1999* (CEPA 1999) under the mandate of Environment and Climate Change Canada.

In the context of the AAS, Health Canada (2016b) notes that its assessment was conducted according to the Codex Alimentarius *Guideline for the Conduct of Food Safety Assessment of Foods Derived from Recombinant-DNA Animals,* concluding that "fillets derived from AAS are as safe and nutritious as fillets from current available farmed Atlantic salmon." Health Canada (2016c) explicitly acknowledges that "[i]n order to protect the scientific integrity of the assessment process, socio-economic factors, such as potential market reaction, are not considered in the decision-making process with respect to novel products." The Codex Alimentarius Guideline (2009) also specifies that it "addresses only food safety and nutritional issues", and does not address concerns about "animal welfare; ethical, moral and socio-economical aspects; [and] environmental risks related to the environmental release of recombinant-DNA animals used in food production" (p. 57). Whether or not these concerns were taken into account by regulators, and if so, to what degree, remains in question. Very little information is provided to the public as to how regulators assess the safety of novel foods and

[6] *Food and Drug Regulations*, CRC, c 870, Division 28, B.28.001. A "novel food" is defined by one of three characteristics: a substance that does not have a history of safe use as a food; a food that has been manufactured, prepared, preserved or packaged by a process that has not been previously applied to that food that causes the food to undergo a major change; or a food that is derived from a plant, animal, or microorganism that has been genetically modified.

what data are used in the evaluation process, apart from brief summaries of product approval decisions posted online after the decision has already been made.

A fulsome assessment of potential environmental and human health impacts of food technologies is crucial to maintaining the safety, resilience, and sustainability of our food systems. Nonetheless, even as this cursory overview goes to show, the existing approach to regulating the products of animal biotechnology demonstrates serious deficiencies both in its breadth and depth. For example, the Science Assessment produced as a result of the Department of Fisheries and Oceans' risk assessment of the AAS was based largely on information provided by the company and not verified by an independent third party. Although it was not determinative, this document was foundational to the AAS approval process in that it informed a finding of non-toxicity according to the requirements under the CEPA 1999,[7] and was used in order to make recommendations on any necessary risk management measures to Environment and Climate Change Canada (Fisheries and Oceans Canada, 2013, p. 1). However, many of the findings contained therein indicate a concerning lack of certainty regarding environmental and indirect human health impacts, especially over the long term. As a case in point, "[w]hile confirmation of sex is not routinely conducted, AquaBounty reports never to have found a 'true' male…and have provided evidence in which all sampled fish were determined to be females" (Fisheries and Oceans Canada, 2013, p. 5). It is highly problematic that confirmation of sex is not routinely conducted and that the evidence of all sampled fish being female was not independently confirmed by a party other than AquaBounty, but the report states that "it is concluded that the generation of an all-female population through gynogenesis has been successful" (Fisheries and Oceans Canada, 2013, p. 5).

Further, under the subheading of "Life history, behaviour and reproduction", the document states, *inter alia*, that "[l]imited information about the behaviour of AAS is available. AquaBounty reported normal avoidance, feeding and postural behaviour of juvenile AAS in a hatchery environment… There is no information available about the predatory behaviour of AAS or AAS-relatives in the natural environment" (Fisheries and Oceans Canada, 2013, p. 7). Additionally, it is explicitly acknowledged that although triploid AAS females are expected to be functionally sterile, "the process of generating triploids at a commercial scale is not always 100% effective. AquaBounty's proposed sampling procedure to select eggs for export ensures a minimum of 95% triploid induction efficacy. There is no information on the reproductive behaviour of female AAS (both diploid and triploid); *a significant knowledge gap* [emphasis added]" (Fisheries and Oceans Canada, 2013, p. 7). This means that up to five percent of AAS salmon may be able to reproduce. If an escape of an AAS were to occur, interbreeding could occur with wild Atlantic salmon and some species of trout, which could lead to genetic contamination and other unpredictable ecological consequences (Oke, Westley, Moreau, &

[7] CEPA 1999, c 33, s 64. A substance is deemed to be toxic if it is entering or may enter the environment in a quantity or concentration that: a) has or may have an immediate or long-term harmful effect on the environment or its biological diversity; b) constitutes or may constitute a danger to the environment on which life depends; or c) constitutes or may constitute a danger in Canada to human life or health.

Fleming, 2013). The fact that such an event has not yet transpired should not be taken glibly as an assurance that it will not occur in the future.

Certainly, attempting to balance competing concerns is never an easy exercise. The goals of supporting the biotechnology industry and protecting public safety and environmental health are challenging to reconcile, especially against a backdrop of mounting public discord and scientific uncertainty about both short- and long-term impacts of new food technologies. Tracing the history of Canadian biotechnology policy, Elisabeth Abergel and Katherine Barrett (2002) contend that Canada's economic interests in the strong uptake of biotechnology have influenced the development of a national biotechnology policy and regulatory system that is overly permissive and favourable to industry. Other scholars have also flagged concerns with the current regulatory process, including that it is opaque, exclusionary, and fragmented (Andrée, 2002; Brunk & Hartley, 2012; Phillipson, 2008). Their call for institutional reforms appears to have gone largely unheeded, evidenced by the ongoing failure to broaden the myopic horizons of policymaking in this area.

Much of the existing political discourse on new food technologies has centred on discussions of risk, which are frequently framed as technical questions best resolved by experts (Kleinman & Kloppenburg Jr., 1991). However, scientifically establishing the existence of a risk does not determine whether the risk so identified is a socially and ethically acceptable one (Rollin, 2006). Moreover, many complex problems are not amenable to this kind of atomistic analysis. Given the social, political, economic, and ethical contexts that food occupies, technical evaluations of new food technologies are conspicuously incomplete, and require a more nuanced consideration of their systemic implications. This is especially the case considering that the self-referential circuit between science and law is perversely reinforced by the feedback loop between state interests in economic development and industry interests in generating profit. The internal logic of these systems makes them especially difficult to challenge; as a result, attempts to express and establish different frames of meaning must target the presumed and imposed terms of the existing discourse.

Ecofeminism

Ecofeminism is a political and philosophical movement that sees the subordination of women and the domination of nature as closely linked. First emerging in the 1980s as an outgrowth of the environmental and women's movements that were flourishing at the time, ecofeminism has since become a diverse movement encompassing a range of different perspectives. In general, the common thread uniting ecofeminist perspectives is a "recognition that solutions to ecological problems must be tied to social and gender transformations" (Sachs, 1992, p. 6). To this end, ecofeminists are committed to exposing systemic causes of discrimination as an underlying cause of gendered and other forms of oppression, including on the grounds of class, race, and species (McLeod-Kilmurray, 2008, pp. 136-137).

In their efforts to include and value alternative forms of knowledge and knowing, ecofeminists "reject the epistemological strategy that views objective facts as central to the process of justifying moral claims" (Gruen, 1994, p. 121), and instead "recognize that claims to knowledge are always influenced by the values of the culture in which they are generated" (Gruen, 1994, p. 124). The feminist emphasis on the experiential perspective begins with the understanding that lived experiences are legitimate forms of knowledge that can give rise to constructive criticisms of existing distributions of power (Rhode, 1990). Rather than claiming a superior authority or a unitary stance, feminist positionality "acknowledges the existence of empirical truths, values and knowledge, and also their contingency" (Bartlett, 1990, p. 880). This reflexivity makes (eco)feminism an especially illuminating perspective in the context of food, which is in itself laden with social, cultural, and ethical values.

Ecofeminism is also inherently skeptical of science and technology, and the associated "mechanistic, reductionist, and fragmented approaches to understanding the natural world that result in the development of unsafe, harmful technologies that are meant to conquer and subdue nature" (Sachs, 1992, p. 6). The problematic conceptual framework—which Karen Warren (1987) defines as "a set of beliefs, values, attitudes, and assumptions which shape, reflect, and explain our view of ourselves and our world" (p. 6)—underlying patriarchal cultures tends to oversimplify the relationship between humans and Nature, such that a relationship based on domination and control is seen as both possible and defensible. Science and technology are socially constructed practices; consequently, they do not merely deliver certain ends, but also impact, transform, and create material, social, and ethical structures. Accordingly, it is important to consider not only the technical attributes and promissory possibilities of new food technologies, but also the worldviews and power relations that are being imported in turn.

Ecofeminism has only rarely been combined with legal analyses. However, as Linda Malone (2015) argues, "it would be a missed opportunity not to revisit the concept of ecofeminism with today's world structure and the pressing problems of international environmental degradation" (p. 1446). Indeed, ecofeminism can help improve the law by proposing alternative conceptual frameworks as well as practical reforms. As Heather McLeod-Kilmurray (2008) points out, "[e]cofeminist legal analysis can uncover inherent biases within the law that not only fail to solve, but help to create or perpetuate structures, mindsets and institutions that lead to environmental harm" (p. 133). Damaging structures and mindsets constantly inform and maintain one another, making it difficult to uncover inherent biases, especially when they become codified in laws and policies that are justified as being "science-based"—the implication then being that they are objective and neutral.

Yet, the boundaries between the scientific and the social are porous, and the determinations of what counts as relevant knowledge, and the further implications of those distinctions, are closely tied to flows of power that are often rendered invisible by their sustained dominion. No one set of interests is "natural, objective, and inevitable" (Bartlett, 1990, p. 886). Left unchecked, dominant paradigms and their adverse consequences will continue to be perpetuated; corrections need to be built into our systems. Although law is part of the problem, it

also can and must be a part of the solution, by giving expression to a variety of perspectives and furnishing opportunities for dissent (Morrow, 2010, p. 75). Thus, a perspective informed by "post-modern ecofeminism" (Malone, 2015, p. 1446), as outlined in the following sections, can expose inherent biases, reject a view of institutions like science and law as being objective, and advance methods and rationales for a different kind of decision-making, guided by more explicitly ethical frames of reference.

An ecofeminist perspective on new food technologies

Starting from the premise that the impacts of technologies often play out in unpredictable and inequitable ways, an ecofeminist perspective on food products of animal biotechnologies acknowledges the fact that, by themselves, they are not uncomplicated solutions to what are complex, structural, and systemic problems. As such, it is not only important to consider the distributive concerns raised, but also to suggest that demand-side approaches warrant at least as much consideration as supply-side approaches to mitigating the impacts of industrial animal agriculture. In considering the four domains below—institutional, environmental, socio-economic, and animal—in the context of food products of animal biotechnologies, this section aims to add nuance to the contours of the discussion by adopting ecofeminist principles like a skepticism of the promissory potentials of science and technology, an emphasis on intersectional oppression, and an ongoing commitment to reflexivity and relationality in both theory and practice.

Institutions

Institutions play a significant role in cultivating trust in or provoking rejection of technologies. Recent events, including a variety of food safety scares, have spurred increasing distrust of both the private companies that develop new technologies, and the public bodies that regulate them. As animal biotechnologies for food production advance further down the pipeline, questions of how to best balance competing regulatory priorities and uphold the public interest become increasingly urgent.

The significance of this moment is compounded by the relatively slender window of latitude, as choices about technology "tend to become strongly fixed in material equipment, economic investment, and social habit" (Winner, 1980, p. 128). In other words, "the consequences of new technologies can not always be predicted, and by the time it becomes apparent that something is wrong with a technology, both its artifactual form and the social interest surrounding it, have become so entrenched that they represent major barriers to change" (Faulkner, 2001, p. 91). As a result, the deliberate and inadvertent choices we make about technologies and their regulation require serious attention at the earliest possible stages, as do the

different degrees of power and levels of awareness we possess regarding the processes by which these decisions are made.

Presently, science plays a key role in law-making when it comes to new technology, "since it pre-figures and subsequently sets a role in shaping regulatory regimes, grounding standard-setting, and guiding the application of the law in licensing systems. It also plays a key substantive role when regulatory decisions are challenged" (Morrow, 2010, p. 67). Because law is shaped by and reflective of values, the regulatory framework governing animal biotechnology inevitably expresses ethical choices. However, under a purportedly "science-based" approach, these ethical choices are often smuggled in under the guise of neutrality. The narrow scientific remit that currently constrains regulators in Canada "largely prohibits them from considering the full range of concerns held by stakeholders and the public" (Brunk & Hartley, 2012, p. 254), despite their acknowledgment that public opinions of animal biotechnology turn on a much broader array of factors than just scientific ones.

Moreover, the relationship between science, law, and policy is an inherently uneasy one: science is much more comfortable with risk and uncertainty than law, and the context of genetically modified foods starkly illustrates that "a new paradigm for interdisciplinary action is urgently required (Morrow, 2010, p. 57). Science, on its own, does not necessarily provide conclusive answers that can adequately guide the inherently political exercise of decision-making based on calculated costs and benefits. In this way, the science of risk assessment is "falsely definitive, narrowly defining risk as the only relevant element for consideration of a technology's public acceptability and often failing to account for the ambiguity of risk-based research" (Preston & Wickson, 2016, p. 55). Both scientific and political methods of assessing and addressing risk are subject to inherent limitations, and an overly reductive approach can lead to unfavourable consequences.

Rather than categorically rejecting science and technology, philosophical criticisms of technological fixes challenge habitual ways of thinking that continue to reinforce more science as the solution to problems wrought by reductively scientific methodologies, and more technology as the solution to problems wrought by technological fixes. In the case of new food technologies, the push for more research and development "may be more the result of entrenched habits of thought and institutional momentum rather than a rigorous and self-critical science and philosophy" (Scott, 2011, p. 224). Technologies can also serve to deny and delay addressing more deeply rooted issues, thereby working to further preserve the status quo. These processes become particularly insidious when they are uncritically assimilated by the law. As a result, existing structures of domination and oppression are reinforced and perpetuated through various levels of abstraction, including the relevant legal and regulatory frameworks. Using alternative perspectives like ecofeminism to destabilize the underlying tenets of a "science-based" approach to regulating new food technologies is therefore an important first step in inculcating a greater degree of reflexivity within both science and law.

Environmental

Proponents and opponents of animal biotechnologies alike use environmental arguments to bolster their cases. As proponents assert, these technologies can significantly reduce the environmental impacts of conventional meat production. For example, one preliminary study estimates IVM to involve 7-45 percent less energy, 78-96 percent lower emissions of greenhouse gases, 99 percent lower land use, and 82-96 percent lower water use than current industrial meat production practices (Tuomisto & Teixera de Mattos, 2011). Similarly, when it comes to GE animals, AquaBounty boasts that the AAS "is better for the environment and consumers," with their two major sustainability claims pertaining to conserving wild fish populations and reducing carbon emissions ("AquaBounty," n.d.).

However, it is oversimplistic to focus on abstract environmental benefits when it comes to new food technologies. While these early figures and claims are encouraging, they are based on speculative, highly specific use scenarios, and it is uncertain whether these benefits will be borne out to the extent claimed. The full energy, land, and water demands of any food production method, as well as the waste and other by-products created, need to be holistically, as well as comparatively, evaluated in light of rapid population growth and increasingly depleted natural resources.

When considering the effects of shifting towards different production systems, the ancillary advantages and disadvantages of current methods must also be taken into account. For example, livestock provide important ecosystem services (FAO, 2016c), and there are numerous inedible components derived from livestock in addition to the meat they provide, including leather, cosmetics, and pharmaceuticals, for which traditional meat production is often an inexpensive source. As Mattick, Landis, and Allenby (2015) observe, "synthetic substitutes could have greater environmental impacts than animal sources, or cost more, or both." Thus, IVM is not automatically an adequate substitute for the ecosystem services and social benefits provided by traditionally raised livestock and the agricultural sector in general, which stand to be levelled by a wide-scale IVM production system. Though the shortcomings of the current system of industrial agriculture are legion, it is important to consider the systemic implications of any alternative, being as there are upsides and downsides to any path pursued.

Meanwhile, aquaculture is among the fastest growing segments of the global food system (FAO, 2016b). Although conventional aquaculture practices are already controversial from an environmental perspective, the role and importance of fish in addressing issues of global food and nutrition security is increasingly a topic of attention. The potential large-scale commercialization of GE fish and seafood, which could dramatically change the aquaculture sector by, *inter alia*, affecting the viability of small to medium-scale enterprises, demanding intensification of production, and increasing dependence on multinational corporations (Le Curieux-Belfond, Vandelac, Caron, & Séralini, 2009, pp. 178-179), is thus highly relevant to any considerations of the future of food production and consumption, on both the domestic and international scale.

Further, the ecological impacts that could result from the introduction of animal biotechnologies into our food systems are potentially catastrophic. Since both ecosystems and social systems rely on complex interrelationships, even a minor change in inputs or outputs can trigger unexpected effects, including disruptions of fragile ecosystems and irreparable losses of biodiversity. Although scientific breeding "clearly has produced breeds of animals that are remarkably productive… The practice has also led to a loss of many breeds of livestock and fowl, and a decline in genetic diversity within the breeds that survive" (NRC, 2002, p. 21). By emphasizing short-term "productivity," as determined by anthropocentric priorities, animal biotechnologies, in terms of both product and process, run counter to many of the ecological principles that ecofeminism draws on, including: "everything is interconnected with everything else; all parts of an ecosystem have equal value; there is no free lunch; "nature knows best"; healthy, balanced ecosystems must maintain diversity; there is unity in diversity" (Warren, 1987, p. 7). Selective breeding is certainly an important part of agricultural history, but any program of human interference and intensification with natural systems invariably generates new sources of risk and vulnerability, especially if motivated by narrow, highly specific goals like increasing size and speed of growth to boost profits.

Aquatic organisms like the AAS present especially grave environmental threats "because their mobility poses serious containment problems, and because unlike domestic farm birds and mammals, they easily can become feral and compete with indigenous populations" (NRC, 2002, p. 4). Many of the concerns flagged in relation to the AAS are more than hypothetical; for example, "[c]ultivated salmon have escaped into the wild from fish farms and these salmon already pose ecologic and genetic risks to native salmon stocks" (NRC, 2002, p. 11). Alarmingly, research has found that, in the case of GE fish, "many traits that appear to confer an advantage in the short-term could have long-term costs that make them overall detrimental" (Le Curieux-Belfond, Vandelac, Caron, & Séralini, 2009, p. 177). It is particularly important to tread with caution given that environmental effects are often difficult to anticipate, latent in emergence, impossible to reverse, as well as unpredictably synergistic and cumulative.

The precautionary principle is an important guideline within environmental law, and is enshrined in both domestic and international laws and policies.[8] The merits and drawbacks of a precautionary approach to environmental protection have been hotly debated in the literature, with some experts considering it to be vital in protecting ecological and human health (Raffensperger & Tickner, 1999), while critics charge that in its strongest form, the principle presents a virtually impossible burden, thereby working to inhibit and even paralyze economic and social development (Sunstein, 2005). Indeed, taken literally, the precautionary principle would prevent, or at least delay, the commercial development and deployment of new food technologies. That being said, a precautionary approach does not void the potential benefits of a

[8] The most notable international acknowledgment of the precautionary principle is contained in the Rio Declaration, at Principle 15 (United Nations Conference on Environment and Development, 1992). In Canada, the precautionary principle is found in the preamble and in s. 2(1)(a) of the CEPA 1999.

technology, but simply postpones them until more persuasive evidence has been gathered (Batie & Ervin, 2001, p. 449).

There are no clear rules for when the threshold of taking a precautionary approach has been met. However, in the context of novel foods, due to the high degree of indeterminacy about their ultimate systemic consequences, a strong version of the precautionary principle—which effectively reverses the burden of proof (Sachs, 2011)—is arguably justified. Placing the burden of proof on critics to prove the dangers of novel foods as opposed to on proponents to prove their safety has the unfortunate effect of considerably discounting unknown or uncertain variables. As the aphorism goes, absence of evidence is not evidence of absence, but without the onus to prove their case, proponents of novel foods can claim they are benign before any significant consequences have had an opportunity to manifest. This is especially so when the parameters of what counts as evidence, how that is determined, and according to what standard, is established according to considerations made by an insular group. As Karen Morrow (2010) remarks, "[a]cting on even a qualified precautionary basis…represent[s] a challenge to current orthodoxy in legal decision-making, which is based so profoundly on the concept of proof" (p. 63). Subsequently, the task is not simply one of "cobbling new practices to existing frameworks" (Andrée, 2006, p. 387), but one that demands a more fundamental shift in values.

To this end, an ecofeminist ethic of care, as an alternative to a highly individualized and hierarchical rules and rights-based ethical model, emphasizes the interconnections between humans, nonhuman animals, and Nature more broadly, and situates these interconnections relationally to one another, which allows the full scope of the complexity of socio-ecological matrix to emerge. By linking production and consumption with processes of regeneration, "ecological feminism creates the possibility of viewing the world as an active subject, not merely as a resource to be manipulated and appropriated" (Mies & Shiva, 1993, pp. 33-34). Such a view not only expands the scope of moral considerability to include the nonhuman, but also reminds us of the collective responsibilities and duties of reciprocation that come with being a citizen of a shared planet. The powers enabled by science and technology should not be taken as a way of abdicating these responsibilities, but should instead be seen as heightening them.

Socio-economic

Although the environmental problems associated with industrial agriculture are deeply troubling, it is also important to recognize that the dominant sustainability discourse is partial, and fails to adequately consider how to improve food and agricultural systems for all people, regardless of how they are situated. Chaone Mallory (2013) notes that "even while food has the potential to inform our very understanding of our place in society and the world, it also carries the risk of obscuring the social infrastructures that keep us ignorant of how food production contributes to social stratification along lines of class, race, and gender" (p. 179). Despite their utopian promises, food technologies can actually retrench existing inequities, while simultaneously

generating new forms of precariousness. Thus, it is important that the full range of their implications are carefully considered from the outset.

In the context of new food technologies, the current Canadian approach to their development and regulation is not promising. The siloed approach observable at present overlooks entire categories of stakeholders, along with their very salient concerns. The lack of meaningful consultation is deeply concerning, because as Sandra Batie and David Ervin (2001) highlight, when innovations "emerge from private laboratories with little contact with farmers or consumers, there may be less sensitivity to farming and eating as part of ecological and cultural systems" (p. 439). Technologies often function very differently in practice than they do in theory, and a limited focus on technical characteristics alone disregards the broader social, economic, and political realities often underlying the problems that the technologies are intended to solve.

Technology plays a significant role in upholding the dominant productionist paradigm in which large-scale industrial agriculture is considered to be the most (or even only) efficient means by which to feed growing populations, because one of the operative assumptions is that scientific and technological ingenuity will ultimately resolve persistent problems of hunger and scarcity. Yet, on the global scale, the number of overweight people has now surpassed the number of malnourished people (World Health Organization, 2016), indicating that when it comes to global hunger, the problem is not one of absolute scarcity, but one of uneven distribution (World Commission on Environment and Development, 1987). Thus, supply-side solutions like GE animals and IVM are unlikely to address root issues, which are more fundamentally social and political. Broader structural transformations of the food and agricultural system are necessary to make it more just and sustainable.

Although it is clear that the problems wrought by industrial meat production are pressing, it is not as clear that animal biotechnologies are an apposite solution. There appears to be very little public appetite for GE animals produced for food consumption (Vàzquez-Salat & Houdebine, 2013), and similarly, new research has revealed that only one third of participants surveyed in the US were definitely or probably willing to eat IVM regularly, or as a replacement for conventionally produced meat (Wilks & Phillips, 2017). This suggests that these are more technology-push developments than demand-pull ones (Batie & Ervin, 2001, p. 438). This characterization mandates a particular need for public scrutiny and ongoing oversight, as technologies created as responses to the demands of wealth, rather than want, will preferentially and inevitably serve the already advantaged (Sarewitz, 1996, p. 131).

Indeed, the results of consumer surveys indicate that "young, white, male, and college-educated individuals are more likely to react favorably to food biotechnology" (Bennett, D'Souza, Borisova, & Amarasinghe, 2005, p. 334). Research has also established that risk perception, more broadly, is not an objective standard, but "may reflect deep-seated values about technology and its impact on society. White males may perceive less risk than others because they are more involved in creating, managing, controlling and benefiting from technology. Women and non-white men may perceive greater risk because they tend to be more vulnerable,

have less control, and benefit less" (Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000, p. 161). However, the so-called "white male effect" as it has been dubbed in the US, where most of this research has been conducted, does not play out the same across all cultures and economic classes (Olofsson & Rashid, 2011). Rather, regardless of race or gender, it is those who stand to benefit most—and those who feel confident that they will have access to treatment or remedies if things go wrong (i.e., suffer the least harm)—that generally seem to perceive less risk when it comes to technological, health, and environmental hazards (McCright & Dunlap, 2013). These findings have serious implications when it comes to the question of how novel foods should be regulated, and who gets to participate in the conversation.

Many scholars have previously called attention to the fact that the scientific research system that exists today "was designed by and for men, and therefore it is men who have established its operations, priorities, standards, and objectives. Men have overwhelmingly made the decisions that determine which equations are solved and which hypotheses are tested" (Sarewitz, 1996, p. 43). The continuing devaluation and invisibility of women's and other marginalized perspectives is readily apparent when considering how new food technologies are developed and regulated. Science, technology, and business remain dominated by men, and the underrepresentation of women is especially glaring in agricultural sector. As Allen and Sachs (2007) report, "of 11 major U.S. industries, agriculture has historically been the least likely to employ women as managers, executives, or administrators" (p. 8). Despite the importance of food to women's lives, "[d]ecisions related to agriculture and food often rely on science and scientific data about agricultural production and food that contain little input from women" (Allen & Sachs, 2007, p. 8). With the increasing scientization and commoditization signalled by new food technologies, the values, knowledge, and experience of women are persistently sidelined, and existing power structures further reinforced.

Regardless of where the production of animal biotechnologies would be situated, the environmental and social externalities can be shifted, at least to some degree, to the less powerful—according to capitalist market logic, the production of commodities is generally governed by the imperatives of low costs and reduced accountability. Within the existing meat processing industry, immigrants and other marginalized groups comprise a significant percentage of the workforce, both in the US (Kandel & Parrado, 2005) and Canada (Charlebois & Summan, 2014). Although these jobs are often dirty, dangerous, and difficult, it is still important to consider how the existing labour market would be affected by a shift towards a different meat production system, especially given the separation between meat consumption and meat production processes (Gouveia & Juska, 2002). The relationship between agricultural technologies and poverty is highly contextual, and attention to this deeper context, rather than a blind focus on the technologies or their outputs themselves, can illuminate critical dimensions of socio-economic conditions that determine where the benefits or burdens fall (Adato & Meinzen-Dick, 2007, p. 3).

The growing dependence on science, technology, and industry along all stages of the food chain means that within highly centralized and industrial systems, the majority of the profits

will continue to "accrue to major food corporations and reduce the possibility of livelihoods of small farmers" (McLeod-Kilmurray, 2012, p. 79). As Vandana Shiva (2000) argues, "[w]hat we are seeing is the emergence of food totalitarianism, in which a handful of corporations control the entire food chain and destroy alternatives so that people do not have access to diverse, safe foods produced ecologically" (p. 17). Even while they present alternatives to the destructive practices of industrial production, new food technologies could also extinguish more viable options, such as a move towards less-intensive farming, restoring more traditional farming practices, and encouraging reduced meat and seafood consumption. Eliminating the ecological and social infrastructure necessary for alternative agricultural practices—however perverted these may have become by industrial processes—would be an error that may prove irreparable. What is lost in the process of adopting new food technologies may not necessarily be commensurate with what is gained.

Animal

Public concern about animal welfare and animal rights is increasing, even while the global appetite for animal products grows (Hume, Whitelaw & Archibald, 2011, p. 10; Murray & Maga, 2010, pp. 358-360). This paradox is partly attributable to the objectification and commoditization of animals that has occurred under an intensive industrial agricultural system, and the laws that enable these processes (McLeod-Kilmurray, 2012). Against this backdrop, some animal biotechnologies for food production, like IVM, are claimed to be one way of reducing the unconscionable degree of animal suffering and death that occurs under the current industrial meat production system, and some thus assert that we may, in fact, have a moral obligation to pursue them (Hopkins & Dacey, 2008, p. 595).

Yet, it would be fallacious to assume that biotechnology offers a clear way out of animal exploitation. IVM technology, at present, still relies to a large degree on animals and animal products (Stephens, 2015), and it is not readily apparent whether the promissory potentials of new food technologies are worth the difficult road to getting there, especially considering the less than enthusiastic public response. Moreover, in the context of genetic engineering, "even modifications like disease resistance that by their very nature are supposed to enhance the welfare of the animal can de facto compromise welfare" (Pascalev, 2006, p. 214), and noble intentions cannot justify harmful outcomes. Additionally, as Zipporah Weisberg (2015) points out, "[t]o suggest that biotechnology will reduce the numbers of animals needed for experimentation is misleading given how many animals will have to suffer in laboratories in order to accomplish such a feat" (p. 49). Improving interspecies relationships demands more from us than just transforming the material conditions in which problematic attitudes and behaviours towards animals endure without question.

Over and above concerns about animal welfare, challenging and unprecedented questions are raised by the ontological, epistemological, and ethical boundary work necessitated by new food technologies (Stephens, 2013; Weisberg, 2015), to which easy answers cannot readily be

found within dominant discourses. Traditional animal welfare and animal rights approaches—which tend to prefer reason over emotion as a guide to ethical decision-making—are not necessarily adequate to explain why many people feel an intrinsic revulsion at manipulating animals for human benefit, even though a particular practice or technology "does not violate a right and does not cause pain or suffering" (Pascalev, 2006, p. 216). Thus, an ecofeminist perspective, with its more explicitly ethical forms of reference, can offer additional insights and guidance in this respect. As Greta Gaard (2002) suggests, "it is not reason alone, but rather the combination of sympathy and a reasoned analysis of cultural and political contexts that provides a more reliable guide to ethics and action" (p. 123).

A contextual ecofeminist ethic involves a shift from a conception of ethics "as primarily a matter of rights, rules, or principles pre-determined and applied in specific cases" (Warren, 1990, p. 141) to instead make "a central place for values of care, love, friendship, trust, and appropriate reciprocity" (Warren, 1990, p. 143). In the context of food, "[t]o *choose one's diet* in a patriarchal culture is one way of politicizing an ethic of care. It marks a daily, bodily commitment to resist ideological pressures to conform to patriarchal standards, and to establishing contexts in which caring for can be nonabusive" (Curtin, 1991, p. 71). Food choices matter, not only to individuals, but to human and natural systems on a global scale.

Although for some, vegetarianism or veganism is implicitly or explicitly identified as an integral part of ecofeminist praxis (Curtin, 1991, pp. 68-71; Gaard, 2002), the ecofeminist perspective presented here does not necessarily advocate for universal vegetarianism or veganism. Instead, it seeks to "address the fact that our meat-advocating culture has successfully separated the *consequences* of eating animals from the *experience* of eating animals" (Adams, 1991, p. 129). New food technologies arguably do little to rescue animals from becoming "absent referents" (Adams, 1990, p. 20); if anything, they contribute to an even further visual and cognitive disconnect between meat as a food product and the animal from which it came. To this end, the aims and outcomes of new food technologies may actually run counter to the goal of transforming the values and beliefs that underpin exploitation, as opposed to simply mitigating the extent of harm.

As Richard Twine (2014) observes, "[t]he political crux of ecofeminism and kindred accounts of intersectionality is to not only create cultures in which other animals matter, but to move "culture," precisely, away from norms of animal exploitation" (p. 205). Animal biotechnologies for food production present an opportunity to pause and reflect on the ethical implications of our food choices and the ways in which interspecies relationships could conscientiously be improved, especially taking into account the interrelated social and environmental problems associated with meat consumption. Presently, "the vegetarian option is largely soft-pedaled on the assumption that as long as meat-eating options are available, most will prefer to exercise that option" (Pluhar, 2010, p. 461). The tacit affirmation of the cultural centrality of meat signalled by animal biotechnologies leads to the conclusion that "veganism is not a live option for actual human societies as they now stand and the real choice is therefore between cultured meat and slaughtered meat" (Hopkins & Dacey, 2008, p. 593). Thus, by

reaffirming the cultural visibility and inevitability of meat consumption, new food technologies entrench the existing hierarchy of food in Western diets, which places the highest symbolic value on flesh foods and the lowest value on plant foods (Twigg, 1983).

Animal consumption is admittedly an entrenched norm for many groups, and this type of norm is not easily altered. Research into food choices has demonstrated that many motivations, from price to cultural-oriented values, influence consumer decision-making. With respect to meat in particular, factors like "strength, health, masculinity, [and] indulgence, are of special importance" (de Bakker & Dagevos, 2012, p. 881). That being said, the food choices people make have a demonstrable capability to evolve on both a personal and societal level. This is especially the case considering that meat's meaning is deeply embedded in a political-cultural context, albeit one that is seldom acknowledged. As Adams (1990) puts it, "[n]one of us chooses the meanings that constitute the texts of meat, we adhere to them. Because of the personal meaning meat has for those who consume it, we generally fail to see the social meanings that have actually predetermined the personal meaning" (p. 24). Given the prerogative of those in the dominant order to set the boundaries of conversation and critique, the fundamental biases underlying meat eating are rarely challenged (Bailey, 2007).

According to an animal justice or animal liberation perspective, animal biotechnologies appear as less of a solution and more of a symptom of the violent subjection of nonhuman animals within industrial capitalist cultures (Miller, 2012, pp. 44-45). When considered thusly, technologies like IVM can act "as an important site for scrutinizing existing socio-cultural narratives about carnivoracity, human-animal relations and agri-biotechnology applications" (Dilworth & McGregor, 2015, p. 104). Neither animal exploitation nor meat eating should be accepted as uncomplicated givens, so as not to simply accept what is for what will always be. Reframing meat consumption as an ethically and politically relevant choice rather than a culturally determined inevitability allows us to better consider how instruments like law and policy can be used to influence our decision-making in positive ways.

Conclusion

As the possibilities enabled by science and technology expand, so too do the scope and scale of the concerns raised. However, the worldview espoused by technologists tends to elevate the importance of machinery while simultaneously devaluing the ethical or spiritual principles that challenge it (Worth Bailey, 2005, p. 9). Accordingly, proponents of new food technologies often dismiss critics as Luddites or technophobes, who reject technology for reasons irrational or otherwise unfounded. This position implicitly codes technocentrism as the neutral stance, while failing to acknowledge that there is a plethora of reasons to be skeptical of technology, regardless of (or even because of) its purported intent.

A healthy skepticism about science and technology does not necessarily signify an anti-science or anti-technology stance. Rather, it indicates a concern about the differential and often

destructive impacts that dominant perspectives on science and technology have generated. Many critics do not shun technology outright, but rather, call for a less taken-for-granted approach to technoscientific systems that, for example, present new food technologies as a direct, straightforward response to the problems caused by industrial flesh food production. Science and technology have certainly enabled many benefits to human society, and they unquestionably have a continuing role to play in any vision of a sustainable future. However, when embedded within the organizing premises of conventional liberal legalism and tied to the drive for profit and power, science and technology are readily turned into tools for advancing a singular kind of rational efficiency, one that has tended to be damaging and exploitative (Rothschild, 1981, p. 66).

Certainly, different perspectives, which are informed by different value considerations, often lead to different points of emphasis. While enthusiastic proponents of scientific and technological innovation writ large have clamoured to embrace new food technologies as a "win-win" solution to many interconnected social and environmental problems, an ecofeminist perspective challenges the emancipatory potentials of science and technology. A more cautious view does not take it as an uncomplicated given that technological palliatives intrinsically lead to societal good. Although unintended consequences may take the form of surprising benefits, as opposed to unforeseen harms, this also raises the question of who benefits and who is harmed in each respective instance.

To be sure, the harms engendered by the current system of industrial animal agriculture are immense, and continuation of a business-as-usual approach is indefensible. Yet, meat eating is a complicated phenomenon, and novel foods, in and of themselves, will not necessarily shift us towards more ethical modes of producing and consuming food. The creation and maintenance of resilient, just, and sustainable food systems depends in large part on local knowledge and context-sensitivity. A blinkered focus on technological fixes renders them less solutions than symptoms of existing problems, which fail to consider simpler approaches (and the incentives that could be facilitated for these) as live options. Through technological "solutions", unsustainable consumption patterns (especially in the developed world) are not challenged, but tacitly endorsed. Supply-oriented approaches ultimately misapprehend underlying problems related to demand and distribution. Framing the problem as one of either producing abundance through biotechnology or leaving people to starve and animals to suffer is a false dilemma. When science and technology are not seen as a silver bullet, energies may be better redirected to addressing the root causes underlying many of the inequities of the global food system.

Laws and regulatory systems need to be more explicit about the ethical and political choices that underpin them in order to move past a "perpetual state of status quo" (Létourneau, 2000, p. 189). Science, technology, and the laws and policies that regulate them are not disembodied practices, but are intimately located within broader realities and structures of meaning. Food choices are intensely personal ones, and technical data are a poor surrogate for values; as such, the suitability and utility of a technical model for resolving complex and often competing concerns is unconvincing, especially in the case of animal biotechnologies for food

production, which raise a plethora of social, cultural, environmental, and ethical apprehensions. Science, though still of foundational importance, is not adequate in and of itself as the basis for sound decision-making in the context of new food technologies. Non-scientific concerns should rightfully influence the public policy response to scientific and technological developments for which the full range and impact of potential consequences is not yet clear.

The resolution of complex but common problems demands more humility and more humanity, which, within prevailing paradigms of science and law, are currently conceptualized as anathema. In addition to reflecting on and critiquing dominant paradigms, an ecofeminist perspective offers constructive suggestions for change by emphasizing a different way of seeing and acting on the world, informed by a more reflexive and relational ethical framework. Beginning with the premise that we are co-habitants of a shared planet, an ethics of care recognizes the inescapable interconnections between humans, nonhuman animals, and Nature, and thus sees technology not as a tool of domination and control, but as a potent reminder of our ethical responsibilities. While it is difficult to break out of entrenched paradigms and worldviews, exposing the ethical and epistemological presuppositions which have hitherto been taken for granted allows us to envision the reconstructive processes that might better address the multivalent concerns raised by new food technologies.

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