Consumer and regulatory response to climate change-new plant breeding techniques

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Abstract. Climate change is having a significant impact on the global grape and wine sector. We are seeing earlier and more compressed vintages, more extreme weather events, and a warming of temperatures. These are all leading to management changes in both the vineyard and the winery. Overlaying these physical changes are the mega-consumer trends that are demanding more sustainable production patterns. These trends are changing consumer attitudes to many previously held beliefs. Solutions with a trend toward a sustainable and agrochemical-free agriculture and production chain are needed. Technological advances in plant genetic engineering, coupled with the sequencing of the grapevine genome, has enabled new techniques that can rapidly be used to enhance positive characters in grape vines and wine. Changing consumer attitudes have led to a number of regulators reviewing their existing food regulations for genetically modified (GM) food. The debate around the definitions for GM food and whether these are fit for purpose since the emergence of a range of new techniques for genetic modification has the potential to dramatically change the landscape for grape and wine production internationally. In this paper we explore the current regulatory developments, consumer trends and attitudes and the implications for the grape and wine sector as we seek to cope with the demands of climate change and provide a sustainable future for the planet.

1 Introduction

Traditional grape varieties suitable for winemaking are not always suited to growing conditions the sector is facing due to climate change. Heat waves, periods of limited water supply and in some areas increased rainfall and humidity lead to challenges to produce high quality wine. There is considerable effort being made to identify grape varieties that are better adapted to these conditions, and in parallel to produce new grape varieties were needed that would survive in these challenging conditions. Another more contemporary challenge is to more profitably compete in a fiercely contested global marketplace. All producers must continue to improve the competitiveness of its wine, dried grape and table grape businesses through productivity gains, innovation, differentiation and meeting market demand.

Worldwide, grapevine breeding program have led to novel grape varieties providing a range of delivered and potential impacts, including increased yield and grape quality, resilience in hot inland environments, and novel product options for growers. As a result, the wine and grape industry has improved capacity to reduce costs and to increase sales in a competitive global marketplace.

The production of new grape characteristics is needed in in order to meet challenges associated with conditions such as tolerance of arid environments, including limited water supply and heat waves, drought events and tolerance of alkaline soils.

Breeding, as opposed to importing, allows an industry to be strategic in many ways. For example, traits that will make a commercial difference can be selected for as a high priority. Moreover, it is not always possible to obtain new varieties from overseas due to utilisation of plant breeders' rights and other forms of protection for new cultivars, adoption of exclusive distribution and/or marketing arrangements or to simple restrictions on the export of new cultivars to establish marketing advantages. This is now the case with USDA varieties which are not patented but their export is prohibited until they are established commercially in the USA. The capability of the our sector to meet these challenges may be limited by the restricted number of grape varieties currently grown. There is great potential for researchers to exploit scientific and technical solutions to meet these challenges.

Within Australia, grapevine breeding is the most prominent method used for the improvement of grape varieties and is distinct from clonal selection and virus elimination. Vine improvement through breeding in this analysis includes the production by hybridisation of new varieties better suited to Australian conditions. Grapevines are bred for specific purposes, including to produce wine grapes, dried grapes, and table grapes.

In Australia, CSIRO's wine grape breeding aims to develop varieties suited to the hot regions which produce a large percentage of Australia's wine grapes. Usually there is very little leeway in hot areas between the time at which the sugar in the grapes reaches the desired level and that at which the acid falls too low. Only cooler areas escape this problem of a very short period of optimum maturity. What is required are varieties with a distinctive flavour and aroma, excellent colour and tolerance of heat, and if possible, suitability to modern production methods and for mechanical harvesting without damage. The wine grape breeding is complemented by vine management research aimed at optimising canopy function with decreased inputs while maintaining wine aroma, flavour, and colour. The intention is to better understand the vine's ability to respond to strategically applied water deficits to enhance berry composition and wine quality, but also to ensure carry-forward of sufficient carbohydrate reserves from one season to the next. Ideally, the new wine grape varieties are suited to these modern production methods.

However, traditional plant breeding techniques are slow and expensive. Techniques using genetic modification have also been limited by a reluctance of consumers and producers to embrace such technologies. However, the development of NBTs provide opportunities to provide innovations that are acceptable to consumers. Unlike transgenic genetically modified organisms (GMOs), gene editing does not necessarily require the insertion of foreign DNA to produce many desired traits. Use of the CRISPR/Cas9 nuclease system, due to its relative simplicity, accuracy, and lower cost has changed the landscape for plant breeding (Selfa T., Lindberg S., and Bain C. 2021). These technologies allow scientists to produce novel traits for food and agricultural products, such as increased nutritional content, delayed spoilage, and improved resilience to drought or disease.

2 What is genetically modified food?

Genetically modified food is food that is derived from an organism (plant, animal, or microbe) whose genetic material (DNA) has been changed using modern genetic modification techniques. The techniques are usually called '*gene technology*', '*genetic engineering*', or '*recombinant DNA techniques'*. Organisms modified in this way are called genetically modified organisms or GMOs.

There are a range of techniques for modifying genomes:

- Genome contains new DNA

Techniques such as transgenesis, cisgenesis, and intragenesis involve taking a piece of DNA from one organism and inserting it into the genome of another organism. The result is a genome that contains new DNA.

- Genome unchanged by gene technology

Techniques that are used to produce null-segregants involve an initial organism that has new DNA inserted into the genome (outcome 1 above). The new DNA helps with the breeding process (e.g. makes it faster) but serves no purpose once the objective of the breeding has been achieved. Towards the end of the breeding process only organisms that have not inherited the new DNA are selected for food production purposes.

- Genome changed but no new DNA (genome editing)

These techniques (e.g. CRISPR & ZFN) involve deleting a specific piece of DNA or editing of the DNA without adding new DNA.

New breeding techniques (NBTs) different to the gene technology methods that have been used to transfer genetic materials between organisms are now being used. For example, genome editing is a NBT that is used to "edit" (remove or re-write) the existing genetic material of a plant or animal. These types of "edits" can also be made using a conventional breeding method called mutagenesis, but genome editing is more targeted, giving a level of control that has not been possible before now.

However, the regulatory response to these new technologies has been mixed. The common element is that there is a shared understanding that regulation has not kept up with the science.

3 What is the regulatory environment?

NBT foods are at an early stage of development and currently there are no NBT foods in the food supply in Australia and New Zealand.

There are no fresh whole GM fruit or GM vegetables in the food supply in Australia or New Zealand. The majority of GM foods in Australia and New Zealand are from GM crops grown overseas. Various food ingredients from these crops (e.g. oil, flour, sugar) are used in processed foods, some of which are imported into Australia and New Zealand. Foods derived from these GM crops must be approved and listed in the Code before they can be imported here. Imported food that contains GM ingredients must also comply with the GM labelling requirements (see below). Only three GM crops (canola, cotton and safflower) are approved for growing in Australia (by the Office of the Gene Technology Regulator). No GM crops have been approved for growing in New Zealand.

In Australia and New Zealand all GM foods must undergo a safety assessment by FSANZ before they can be approved. This assessment allows FSANZ to ensure GM foods are as safe as other foods already in the food supply. Approved foods for sale that are GM or contain GM ingredients must be labelled with the statement 'genetically modified'. On packaged food this statement would appear next to the name of the food or next to the specific GM ingredient in the ingredient list.

If the food is unpackaged, the information must accompany the food or be displayed with the food. The labelling requirement applies to food produced in, or imported into, Australia and New Zealand.

Certain GM foods or ingredients are exempt from labelling. For example, GM flavourings that are present in food in a concentration of no more than 0.1% are exempt from the labelling requirement.

4 International definitions

The World Health Organization/United Nations Food and Agricultural Organization Codex Alimentarius definition of biotechnology includes regulating gene editing as GMO (Bain et al., 2020).

5 Recent developments

Australia and New Zealand

Food Standards Australia New Zealand (FSANZ) is a statutory authority in the Australian Government Health portfolio. FSANZ develops food standards for Australia and New Zealand (the Australia New Zealand Food Standards Code (the Code).

The Code is enforced by state and territory departments, agencies and local councils in Australia; the Ministry for Primary Industries in New Zealand and the Australian Department of Agriculture and Water Resources for food imported into Australia.

Australia and New Zealand are reviewing how the Australia New Zealand Food Standards Code (the Code) applies to food derived using new breeding techniques (NBTs). These techniques are new approaches in plant and animal breeding that were not in use when Standard 1.5.2 – Food produced using gene technology – was first developed nearly 20 years ago.

Consultations are focused on how food derived from NBTs should be captured for pre-market approval under Standard 1.5.2 and whether the definitions for 'food produced using gene technology' and 'gene technology' in Standard 1.1.2─2 should be changed to improve clarity about which foods require pre-market approval. In December 2019 FSANZ released a Final Report which made three recommendations:

- **Recommendation 1:** FSANZ prepare a proposal to revise and modernise the definitions in the Code to make them clearer and better able to accommodate existing and emerging genetic technologies.
- **Recommendation 2:** As part of the proposal, FSANZ give consideration to process and non-process based definitions and the need to ensure that NBT foods are regulated in a manner that is commensurate with the risk they pose.
- **Recommendation 3:** Throughout the proposal process FSANZ will ensure there is open communication and active engagement with all interested parties and also explore ways to raise awareness about GM and NBT foods.

In February 2020, FSANZ commenced work on a proposal to amend the definitions for 'food produced using gene technology' and 'gene technology' in the Code (Proposal P1055). The first of two rounds of public consultation was for 8 weeks and closed on 3 December 2021. FSANZ invited interested parties to comment on its proposed approach to:

- revise and expand the process-based definition for 'gene technology' to capture all methods for genetic modification other than conventional breeding; and
- revise the definition for 'food produced using gene technology' to include specific product-based criteria for excluding certain foods from pre-market safety assessment and approval as GM food. Foods that do not meet all relevant exclusion criteria would still require an application to FSANZ.

A second public consultation is scheduled for 2022.

United States

In March 2018, the USDA stated that it did not intend to regulate gene-edited plants if the end product is indistinguishable from products produced through traditional plant breeding and as long as they are not plant pests or developed using plant pests.

In the United St0ates, the FDA oversees the regulation of human food and animal feed by evaluating purity, potency, safety, and labeling. GMOs and gene-edited plants are considered equivalent to, and as safe as, their traditionally bred or mutagenesis-produced counterparts by the FDA (Smyth and McHughen, 2008; Wolt et al., 2016). The FDA has a voluntary plant biotechnology consultation process, in which developers submit a summary of their safety and regulatory assessment to the agency, after which the FDA provides feedback and works with developers to resolve safety issues. The FDA then sends the developer a letter stating they have no further safety concerns but that developers are obligated to ensure safety of the food in the marketplace. In February 2019, the FDA (2021) completed its first consultation on a genome-edited plant variety, a soybean variety modified to have increased levels of a fatty acid called oleic acid.

In 2020, the EPA also stated its intent to modify its oversight of plant-incorporated pesticides (PIPs) in order to exempt products made with newer biotechnologies, such as gene editing, if they are deemed to be similar enough to PIPs created through conventional breeding and are unlikely to present unreasonable risks to humans or the environment (EPA, 2020).

In May 2020, the USDA released the final rule for its biotechnology regulations, 7CFR part 340, called SECURE (Sustainable, Ecological, Consistent, Uniform, Responsible, Efficient) rule for plants developed using biotechnology. The updated SECURE rule states that plants produced through genetic engineering will only be regulated if they pose a risk.

European Union

In Europe, the use of New Breeding Techniques (NBTs) are being considered to contribute to the objectives of the European Green Deal and in particular to the Farm to Fork and Biodiversity Strategies and the United Nations' Sustainable Development Goals (SDGs) for a more resilient and sustainable agri-food system. Examples of potential benefits include plants more resistant to pests, diseases and environmental conditions or to the effects of climate change (e.g. droughts), or requiring less natural resources and fertilizers.

However, historically, consumers have raised concerns linked to the use of these technologies, e.g. on their potential safety and environmental impacts, including on biodiversity, the coexistence with organic and GM-free agriculture as well as concerns on labelling and consumers' right to information and freedom of choice.

However, among NBTs, targeted mutagenesis and cisgenesis can be used to produce alterations of the genetic material that can also be obtained by natural mutations or conventional breeding techniques. The European Food Safety Authority (EFSA) concluded that plants obtained by targeted mutagenesis and cisgenesis can have the same risk profile as plants produced with conventional breeding.

In Europe, a policy initiative on plants obtained by targeted mutagenesis, (where mutation(s) are induced in selected target locations of the genome without insertion of genetic material) and cisgenesis, (where genetic material (e.g. a gene) is inserted into a recipient organism from a donor organism with which the recipient is sexually compatible (crossable) in nature, e.g. a gene from a wild potato into a domesticated potato) is being developed.

The outcome of this policy is likely to be that plants (grapevines) produced using these techniques will not be treated as genetically modified under regulation.

6 Consumer perspectives

It is clear from the literature that people have generally more positive attitudes to NBTs than older GM technologies, despite having relatively low knowledge about them. It appears that both the 'less random' and 'less foreign' aspects of NBTs when compared with older GM technologies.

Within Australia, research has been undertaken that suggests that consumers views on these products has shifted and community members may view NBTs differently compared to older techniques such as genetic modification (or GM). In particular, this research is informing the current review of definitions in the Australia New Zealand Food Standards Code for 'food produced using gene technology' and 'gene technology,' which is being undertaken by Food Standards Australia New Zealand (FSANZ). This review, is now included and FSANZ will shortly announce the commencement of a new process to consider how the definitions for GM foods should be amended.

The decision to exempt most plants from regulatory review in the United States resulted in public condemnation from many mainstream environmental NGOs as well as from some scientists involved in gene-editing research, all expressing concern that allowing companies to self-regulate would heighten distrust in gene editing among consumers (Kuzma, 2019; Montenegro, 2020b; Gordon et al., 2021).

Grant et al. (2021) undertook a literature review of consumer attitudes for FSANZ in 2021. Their findings were that consumers prefer foods produced with NBTs over GM produced food, but less than conventional foods. In this systematic literature review they summarised, assessed, and synthesised the available evidence on the awareness and knowledge, risk perceptions and attitudes, and behavioural responses of consumers to the use of NBTs in the production of food from 146 studies of varying relevance to the question at hand.

Their findings suggest need for a greater understanding about underlying values, policy considerations, and the broader context within which people come to understand technologies such as NBTs. They also found that responses are more positive toward NBTs than GM. Despite the limitations of the existing evidence, this is supported in the literature: attitudes and behavioral responses to NBTs are slightly more positive than toward older forms of GM, though slightly more negative than food produced using traditional breeding techniques. They note it could also be a finding that evolves or vanishes as the prospect of food produced using NBTs becomes more real.

Another observation is that given the relatively low existing awareness of NBTs, ongoing discussion and communication about food produced using NBTs will significantly shape attitudes into the future. While some research has suggested consumers appreciate the potentially 'targeted' nature of NBTs (see Debucquet et al. 2020), and producers appreciate the potential for 'simpler', 'faster', 'cheaper' and 'untraceable' pathways to produce GM organisms, others have suggested that these key aspects may present critical communication challenges (Pirscher and Theesfeld 2018). For example, lack of traceability due to the production of 'nature-identical' GM organisms' makes the prospect of gene editing worse, not better, than older GM for those who oppose any change.

Similarly, the possibilities of being faster, cheaper, and easier resonate with many producers, there is also concerns that some countries may use this as a trade barrier to prevent adoption outside their countries to prevent more efficient production methods being adopted.

Another argument is that labeling may provide and opportunity for consumers to choose. For example, Bechtold (2018) argues that food labelling and consumer choice should be considered as institutions to "support communication about values and to broaden the perspective on the agricultural use of genome editing and its products".

Finally, it was noted that that any deliberation cannot be removed from history: discussions will take place in political contexts that will recall earlier, and oftentimes fractious, debates on GM. Van Eenennaam and Young (2018) note, the public discussions around the first gene edited food organisms will affect discussions about new technologies and food long into the future. Early applications that successfully navigate regulatory hurdles will influence the public discussion around gene edited animals and impact the trajectory of future applications.

Pirscher and Theesfeld (2018) note, to date conventional analytical methods such as PCR (polymerase chain reaction) cannot detect a modified product, but other authors have argued that CRISPR/Cas can leave small amounts of foreign DNA in the genome, rendering the resultant organism in some sense traceable. This means that the question of untraceability may still be unresolved.

As with health policy, well-organized activist special interest groups, frequently focused on a single issue or narrow range of concerns, are often highly influential. Organizations that oppose GMO products are likely to be much more active in the political arena than individual consumers who do not oppose GMO based products and benefit from them (Smith, Wesseler, and Zilberman 2021). Such interest groups may influence policy makers' decisions because they are large and their members and supporters tend follow their leaders' voting recommendations. However, even small interest groups can have a significant impact on voter perceptions of an issue through the information they share via traditional and newer forms of social media and their access and financial contributions to policy makers (Wesseler and Zilberman, 2014).

7 Conclusion

If these techniques are permitted under regulation and treated differently to 'traditional' genetic modification techniques it will provide significant opportunities in the areas of:

- levels and cost of agricultural inputs (e.g. plant protection products, fertilisers), use of natural resources, development of more resilient varieties (e.g. to environmental or specific geographical conditions and plant diseases and pests), capacity to support local agricultural solutions and reduce costs and time in plant breeding.
- Innovation and research in agri-food system, as well as in bio-based and biotechnology industries, will benefit from a framework providing legal clarity and a more adapted regulatory environment for plants produced by targeted mutagenesis and cisgenesis.
- impacts for organic and GM-free agriculture and their premium retail sector (e.g. due to compliance, certification and segregation costs).

However, while consumers appear more ready to accept such products, there is a powerful and well- organized movement to oppose these. However, for the world to be sustainable and meet the United Nations Sustainability Objectives leadership is required. The grape and wine sector has always respected and adopted innovation while respecting its traditions and needs to seriously consider where its future lies.

References

1. C. Bain, S. Lindberg, T. Selfa, Agri. Human Values **37**, 265 (2020) DOI: http://dx.doi.org/10.1007/s10460-019-09980-9
2. G. Debucquet, R. Baron, M. Cardinal, Public Understanding Sci. **29**, 524 (2020) https://doi.org/10.1177/0963662520929668
3. W.J. Grant, H. Bray, R. Harms, R.A. Ankeny, J. Leach, *Consumer Responses to the Use of NBTs in the Production of Food: A Systematic Literature Review* (The Australian National University, Australia, 2021)
4. F. Pirscher, I. Theesfeld, *The Ethical Dilemma With Governing CRISP/Cas Genome Editing. In S. Springer & H. Grimm (Eds.), Professionals in Food Chains* (Wageningen Academic, The Netherlands, 2018) https://doi.org/10.3920/978-90-8686-869-8_66
5. T. Selfa, S. Lindberg, C. Bain, Elem. Sci. Anth. **9**, 1 (2021) DOI: https://doi.org/10.1525/elementa.2020.00153
6. V. Smith, J.H.H. Wesseler, D. Zilberman, Sustainability **13**, 3687 (2021) https://doi.org/10.3390/su13073687
7. A.L. Van Eenennaam, A.E. Young, Nutr. Nat. Resour. **13**, 1 (2018) https://doi.org/10.1079/PAVSNNR2018 13027
8. J. Wesseler, D. Zilberman, Environ. Dev. Econ. **19**, 724 (2014)