



Australian Government

Department of Health, Disability and Ageing

Office of the Gene Technology Regulator

January 2026

Risk Assessment and Risk Management Plan for

DIR 218

Commercial release of tomato genetically modified for purple fruit colour

Applicant: All Aussie Avocados Pty Ltd (trading as All Aussie Farmers)

Summary of the Risk Assessment and Risk Management Plan

for

Licence Application No. DIR 218

Decision

The Gene Technology Regulator (the Regulator) has decided to issue a licence for this application for the intentional release of a genetically modified organism (GMO) into the environment. A Risk Assessment and Risk Management Plan (RARMP) for this application has been prepared by the Regulator in accordance with the *Gene Technology Act 2000* (the Act) and corresponding state and territory legislation, and finalised following consultation with a wide range of experts, agencies and authorities, and the public. The RARMP concluded that the proposed release poses negligible risk to human health and safety and the environment and that any risks posed by the dealings can be managed by imposing conditions on the release.

The application

Applicant	All Aussie Avocados Pty Ltd (trading as All Aussie Farmers)
Project Title	Commercial release of tomato genetically modified for purple fruit colour ¹
Parent organism	Tomato (<i>Solanum lycopersicum</i>)
Genetic modifications	
Introduced genes	<p>Introduced genes conferring purple fruit colour, sourced from garden snapdragon (<i>Antirrhinum majus</i>):</p> <ul style="list-style-type: none"> • <i>Delila</i> gene • <i>Rosea1</i> gene <p>These 2 genes switch on production of natural purple/blue pigments, anthocyanins, in the ripening fruit.</p> <p>Introduced marker gene:</p> <ul style="list-style-type: none"> • <i>nptII</i> gene from the bacterium <i>Escherichia coli</i> conferring resistance to the antibiotic kanamycin and structurally related antibiotics
Genetic modification method	<i>Agrobacterium</i> -mediated transformation
Identifier	<p>Developer's event name: Del/Ros1-N</p> <p>Commercial name: The Purple Tomato™</p> <p>OECD Unique Identifier: NPS-01201-8</p>
Principal purpose	Commercial cultivation of the GM Purple Tomato in greenhouses
Previous releases	<p>Australia</p> <p>The GM Purple Tomato has not been previously grown in Australia.</p> <p>United States (US)</p> <p>The US Department of Agriculture Animal and Plant Health Inspection Service deemed the GM Purple Tomato not a regulated article. Seed has been sold to home gardeners since 2024.</p> <p>The US Food and Drug Administration authorised the GM Purple Tomato as food</p>

¹ The original title for the application was *Commercial release of Lycopersicon esculentum genetically modified for purple anthocyanin pigment in ripe fruit*.

	<p>in 2023. In 2024 and 2025, commercially produced fruit was sold in grocery stores.</p> <p>Canada</p> <p>In August 2025, food safety and unconfined release approvals were granted in Canada.</p>
--	--

Risk assessment

The risk assessment process considers how the genetic modification and proposed activities conducted with the GMOs might lead to harm to people or the environment. Risks are characterised in relation to both the seriousness and likelihood of harm, taking into account current scientific/technical knowledge, information in the application (including proposed limits and controls) and relevant previous approvals. Both the short- and long-term impacts are considered.

Credible pathways to potential harm that were considered included exposure of people or other desirable organisms to the GM plant material, horizontal gene transfer of the antibiotic resistance gene, potential for persistence or dispersal of the GMOs, and transfer of the introduced genetic material to non-GM tomato plants. Potential harms associated with these pathways included increased allergenicity or toxicity to people, toxicity to other desirable organisms, increased antimicrobial resistance and environmental harms due to weediness.

The risk assessment concludes that risks to the health and safety of people or the environment from the proposed dealings are negligible. The principal reasons for the conclusion of negligible risks are that the introduced proteins are not expected to be toxic or allergenic, the *nptII* gene is not expected to increase antimicrobial resistance, tomatoes are not considered to be weedy and the genetic modifications are not expected to make the GM Purple Tomato weedier, and tomatoes have limited ability to naturally hybridise with sexually compatible species.

Risk management

The risk management plan describes measures to protect the health and safety of people and to protect the environment by controlling or mitigating risk. The risk management plan is given effect through licence conditions.

As the level of risk is assessed as negligible, specific risk treatment is not required. However, licence conditions are imposed regarding post-release review (PRR) to ensure that there is ongoing oversight of the release and to allow the collection of information to verify the findings of the RARMP. The licence also contains several general conditions relating to ongoing licence holder suitability, auditing and monitoring, and reporting requirements, which include an obligation to report any unintended effects.

Table of Contents

Summary of the Risk Assessment and Risk Management Plan	i
Table of Contents.....	iii
Abbreviations	v
Chapter 1 Risk assessment context.....	1
Section 1 Background.....	1
1.1 Interface with other regulatory schemes – defining the scope of this evaluation.....	2
Section 2 The proposed dealings	2
Section 3 The parent organism	3
3.1 Production and consumption	3
3.2 Reproduction	3
3.3 Phenotypic characteristics.....	5
3.4 Toxicity and allergenicity of tomatoes.....	5
3.5 Weed risk potential for tomato plants outside cultivation	6
Section 4 The GMO, nature and effect of the genetic modification.....	7
4.1 The genetic modifications in the GMO proposed for release	7
4.2 Method of genetic modification	13
4.3 Toxicity and allergenicity of the proteins associated with the introduced genes.....	13
4.4 Toxicity and allergenicity of the end products associated with the introduced genes	14
4.5 Characterisation of the GMO.....	15
Section 5 The receiving environment	23
5.1 Relevant abiotic factors	23
5.2 Relevant biotic factors	24
5.3 Relevant cultivation practices in Australia	24
5.4 Presence of related species in the receiving environment	25
5.5 Presence of the introduced genes and their encoded proteins in the environment.....	26
5.6 Use of kanamycin, neomycin and related antibiotics in veterinary and human medicine	26
Section 6 Relevant Australian and international approvals.....	27
6.1 Australian approvals	27
6.2 International approvals.....	28
Chapter 2 Risk assessment	29
Section 1 Introduction.....	29
Section 2 Risk identification	30
2.1 Risk source	30
2.2 Causal pathway.....	31
2.3 Potential harm	31
2.4 Postulated risk scenarios	32
Section 3 Uncertainty	46
Section 4 Risk evaluation.....	47
Chapter 3 Risk management plan.....	48
Section 1 Background.....	48
Section 2 Risk treatment measures for substantive risks	48
Section 3 General risk management	48
3.1 Applicant suitability	48
3.2 Testing methodology	49
3.3 Identification of the persons or classes of persons covered by the licence.....	49
3.4 Reporting requirements	49
3.5 Monitoring for compliance	49

Section 4	Post release review	49
4.1	Adverse effects reporting system	50
4.2	Requirement to collect additional specific information.....	50
4.3	Review of the RARMP	50
Section 5	Conclusions of the RARMP	51
References	52
Appendix A: Summary of submissions on matters relevant to preparation of the consultation RARMP ..		64
Appendix B: Summary of submissions from prescribed experts, agencies and authorities on the consultation RARMP ..		68
Appendix C: Summary of submissions from the public on the consultation RARMP.....		70

Abbreviations

AICIS	Australian Industrial Chemicals Introduction Scheme
APHIS	United States Department of Agriculture Animal and Plant Health Inspection Service
APVMA	Australian Pesticides and Veterinary Medicines Authority
ARTG	Australian Register of Therapeutic Goods
ASPCA	American Society for the Prevention of Cruelty to Animals
ASTAG	Australian Strategic and Technical Advisory Group on Antimicrobial Resistance
DAFF	Department of Agriculture, Fisheries and Forestry
Del	Delila
DIR	Dealings involving intentional release
DPA	Days post anthesis (flower opening)
FSANZ	Food Standards Australia New Zealand
GM(O)	Genetically modified (organism)
GTTAC	Gene Technology Technical Advisory Committee
ha	Hectare(s)
HGT	Horizontal gene transfer
HLH	Helix loop helix
kg	kilogram
m	Metre
mg	Milligram
NPTII	Neomycin phosphotransferase type II
OECD	Organisation for Economic Co-operation and Development
OGTR	Office of the Gene Technology Regulator
PRR	Post release review
RARMP	Risk Assessment and Risk Management Plan
ROS	Reactive oxygen species
Ros1	Rosea1
TGA	Therapeutic Goods Administration
the Act	<i>The Gene Technology Act 2000</i>
the Regulations	<i>The Gene Technology Regulations 2001</i>
the Regulator	The Gene Technology Regulator
US	United States
USDA	United States Department of Agriculture
WDR	Tryptophan-aspartic acid-40 repeat
WHO	World Health Organization

Chapter 1 Risk assessment context

Section 1 Background

1. An application has been made under the *Gene Technology Act 2000* (the Act) for Dealings involving the Intentional Release (DIR) of genetically modified organisms (GMOs) into the Australian environment.
2. The Act and the Gene Technology Regulations 2001 (the Regulations), together with corresponding State and Territory legislation, comprise Australia's national regulatory system for gene technology. Its objective is to protect the health and safety of people, and to protect the environment, by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with GMOs.
3. Section 50 of the Act requires that the Gene Technology Regulator (the Regulator) must prepare a Risk Assessment and Risk Management Plan (RARMP) in response to an application for release of GMOs into the Australian environment. Sections 50, 50A and 51 of the Act and sections 9 and 10 of the Regulations outline the matters which the Regulator must take into account and who must be consulted when preparing the RARMP.
4. The *Risk Analysis Framework* (OGTR, 2013) explains the Regulator's approach to the preparation of RARMPs in accordance with the Act and the Regulations. The Regulator has also developed operational policies and guidelines that are relevant to DIR licences. These documents are available from the Office of the Gene Technology Regulator (OGTR) [website](#).
5. Figure 1 shows the information that is considered, within the regulatory framework, in establishing the risk assessment context. This information is specific for each application. Potential risks to the health and safety of people or the environment posed by the proposed release are assessed within this context. Chapter 1 provides the specific information for establishing the risk assessment context for this application.

RISK ASSESSMENT CONTEXT	
The GMO	Proposed GMO dealings
Modified genes	Activities
Novel traits	Limits
	Controls
Parent organism (comparator)	Previous releases
Origin and taxonomy	Australian approvals
Cultivation and use	International approvals
Biology	
Receiving environment	
Environmental conditions: abiotic and biotic factors	
Production practices	
Related organisms	
Similar genes and proteins	

Figure 1. Summary of parameters used to establish the risk assessment context, within the legislative requirements, operational policies and guidelines of the OGTR, and the Risk Analysis Framework

6. Since this application is for commercial purposes, it cannot be considered as a limited and controlled release application under section 50A of the Act. Therefore, under section 50(3) of the Act, the Regulator was required to seek advice from prescribed experts, agencies and authorities on matters relevant to the preparation of the RARMP. This first round of consultation included the Gene Technology Technical Advisory Committee (GTTAC), State and Territory Governments, Australian Government authorities or agencies prescribed in the Regulations, all Australian local councils and the Minister for the Environment. A summary of issues contained in submissions received is provided in Appendix A.

7. Section 52 of the Act requires the Regulator, in a second round of consultation, to seek comment on the RARMP from the experts, agencies and authorities outlined above, as well as the public. Advice from the prescribed experts, agencies and authorities in the second round of consultation, and how it was taken into account, is summarised in Appendix B. Fifteen public submissions were received and their consideration is summarised in Appendix C.

1.1 Interface with other regulatory schemes – defining the scope of this evaluation

8. Gene technology legislation operates in conjunction with other regulatory schemes in Australia. The GMOs and any proposed dealings may also be subject to regulation by other Australian government agencies that regulate GMOs or GM products, including Food Standards Australia New Zealand (FSANZ), the Australian Pesticides and Veterinary Medicines Authority (APVMA), the Therapeutic Goods Administration (TGA), the Australian Industrial Chemicals Introduction Scheme (AICIS) and the Department of Agriculture, Fisheries and Forestry (DAFF). These dealings may also be subject to the operation of State legislation recognising an area as designated for the purpose of preserving the identity of GM crops, non-GM crops, or both GM crops and non-GM crops, for marketing purposes.

9. To avoid duplication of regulatory oversight, risks that will be considered by other regulatory agencies would not be assessed by the Regulator.

10. FSANZ assesses the safety of food produced using gene technology through administration of the *Australia New Zealand Food Standards Code*. FSANZ received an application related to the GM Purple Tomato, A1333, and their assessment found that food derived from the GM Purple Tomato is as safe as food from conventional tomatoes already in the Australian and New Zealand food supply. In October 2025, FSANZ approved this GM Purple Tomato for sale as a food in Australia and New Zealand. The GM tomatoes and any derived food products are subject to mandatory GM labelling. More information is available on the [FSANZ website](#).

11. DAFF is responsible for administering various biosecurity measures. The applicant has proposed to import the GM Purple Tomato seeds into Australia from the United States (US). These imports would be subject to permits obtained from DAFF.

12. The applicant has stated that the increased anthocyanins in the GMO could have health-promoting effects. Claimed benefits of the GMO are outside the scope of the Gene Technology legislation. The Regulator's responsibility is to identify and manage risk as a result of gene technology.

Section 2 The proposed dealings

13. All Aussie Avocados Pty Ltd (the applicant), trading as All Aussie Farmers, is seeking approval to commercially grow a GM Purple Tomato (Organisation for Economic Co-operation and Development/OECD Unique Identifier: NPS-01201-8). The proposed release would be Australia-wide, subject to restrictions imposed under any applicable legislation other than the Gene Technology legislation. The GM Purple Tomato and its products would enter general commerce including use in human food.

14. The dealings involved in the proposed intentional release are to:

- conduct experiments with the GMO
- breed the GMO
- propagate the GMO
- use the GMO in the course of manufacture of a thing that is not a GMO
- grow, raise or culture the GMO
- import the GMO
- transport the GMO
- dispose of the GMO

and the possession, supply or use of the GMO in the course of any of these dealings.

Section 3 The parent organism

15. In establishing the risk context, details of the parent organism form part of the baseline for a comparative risk assessment (OGTR, 2013). Non-GM tomato is the standard baseline for biological comparison in this RARMP.

16. The parent organism is tomato, *Solanum lycopersicum*, also known as *Lycopersicon esculentum*. Tomato plants are exotic to Australia. Modern cultivated tomatoes (*S. lycopersicum* var. *lycopersicum*) originated from wild tomatoes in Peru, Ecuador, and other parts of South America, with domestication then occurring in Mexico. The wild cherry tomato *S. lycopersicum* var. *cerasiforme* is a weedy variety of tomato that is recognised to be closely related to cultivated tomatoes (Nesbitt and Tanksley, 2002). In this RARMP, *S. lycopersicum* and tomato are both terms that are used to refer to modern cultivated tomato *S. lycopersicum* var. *lycopersicum*, unless otherwise specified. Wild relatives include *S. cheesmaniae*, *S. pennellii*, *S. pimpinellifolium*, and *S. chilense* (Peralta et al., 2008).

17. Tomato plants belong to the family *Solanaceae*, also known as the nightshade family, which includes other edible crops like eggplants, capsicums and potatoes.

18. Botanically, the fruit of the tomato are berries, i.e. a simple fruit with many seeds in its flesh. In a culinary context, tomatoes are considered to be vegetables and are commonly used in a variety of savoury dishes.

3.1 Production and consumption

19. Tomatoes are grown both commercially and by individuals. Relevant agricultural practices for tomatoes in Australia are discussed further in Section 5.3.

20. Globally, over 192 million tonnes of tomatoes were produced commercially in 2023, with Australia accounting for approximately 0.17% of global production (Table 1). The ripe fruit of tomatoes are consumed either raw or cooked. Tomatoes may be processed and preserved as products such as juice, soups, dehydrated powder, salsas or sauces. Tomatoes are a popular food around the world, second only to potatoes when considering vegetable consumption. The average global consumption of tomatoes and tomato products is estimated at 22.25 kg/person/year for 2022, with Australia having an above average consumption at 37.16 kg/person/year ([FAOSTAT website](#); accessed 10 July 2025).

Table 1. Production of tomatoes (2023)

Region	Area harvested (ha)	Yield (kg/ha)	Production (t)
World	5,412,458	35,533	192,317,973
Australia	4,055	79,340	321,736

Source: [FAOSTAT website](#) (accessed 10 July 2025). Data rounded to nearest whole number.

3.2 Reproduction

21. Tomatoes reproduce sexually and are primarily propagated through seed, although the plants also grow readily from cuttings and have a high capacity for the formation of adventitious roots (roots that form at the base of cuttings, stems in contact with soil etc.) (Guan et al., 2019; Nkongho et al., 2023).

22. After a seedling emerges, tomatoes undergo a vegetative growth period of approximately 2 to 3 months before flowering (Fullelove et al., 1998).

23. Most wild tomatoes and some intermediates to domesticated varieties have an exserted/elongated stigma (the pollen-receiving part of the female reproductive organ) which facilitates cross pollination by other sexually compatible plants. Domestication of wild tomato varieties has resulted in selection for a

shortened stigma. As such, modern tomatoes are self-compatible and primarily self-pollinating (Peralta et al., 2008). A small amount of cross pollination is observed (usually about 0 – 1.75% at 1 m or less between plants), although cross pollination rates may be increased based on cultivar and environmental conditions (Horneburg et al., 2018; Quirós and Marcías, 1978; Reeves, 1973). Some heirloom varieties of tomatoes display a partially exserted stigma, which increases the likelihood of cross-pollination (McCormack. J, 2004).

24. Movement of the flower is important for releasing tomato pollen. In a field setting, vibration of the flower is provided by wind and insects, particularly bees, also known as buzz pollination (Bashir et al., 2018; OECD, 2017). In a greenhouse setting, pollination is aided artificially by methods such as vibrating the flowers with an electric toothbrush, tapping the flower cluster several times with a pencil or using fans to create air movement across the flowers (McCormack. J, 2004).

25. Following pollination, tomato fruit then forms. In a commercial setting, it normally takes 6 – 8 weeks from first flower to fruit harvest (Fullelove et al., 1998).

26. As described in the United States Standards for Grades of Fresh Tomatoes (USDA, 1991), there are 6 main phases in red tomato fruit ripening (Figure 2);

- **Mature green:** the surface of the tomato is completely green in colour
- **Breaker:** there is a definite break in colour from green to tannish-yellow, pink or red on not more than 10% of the surface
- **Turning:** more than 10% but not more than 30% of the surface shows a definite change in colour from green to tannish-yellow, pink, red, or a combination thereof
- **Pink:** more than 30% but not more than 60% of the surface shows pink or red colour
- **Light red:** more than 60 percent of the surface shows pinkish-red or red AND not more than 90% of the surface is red
- **Red:** more than 90 percent of the surface shows red colour.

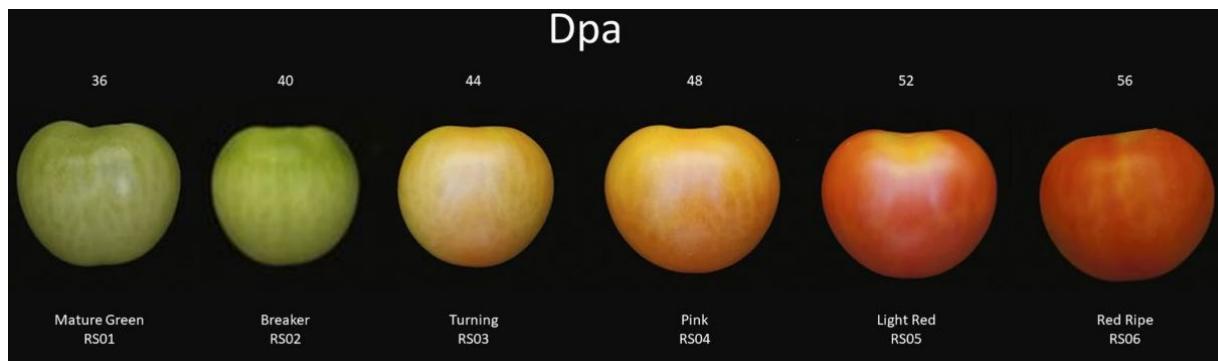


Figure 2. Tomato ripening phases

Source: Skolik et al. (2019). Ripening phases of *Solanum lycopersicum* cv. MoneyMaker. Dpa = days post anthesis (flower opening).

27. Fruit species can be classified on the basis of whether they continue to ripen after harvesting (climacteric) or must ripen fully on the plant (non-climacteric). Climacteric fruit, like tomatoes, bananas, and avocados, demonstrate increased respiration rates and ethylene synthesis during ripening and will continue to ripen off the plant (Giovannoni, 2004).

28. Each tomato fruit typically contains 150 to 300 seeds (McCormack. J, 2004).

29. Tomatoes have evolved mechanisms to prevent the germination of seeds while the fruit is still on the plant, also known as precocious germination. Tomato seeds are coated with a gel-like mucilage layer that acts as a germination inhibitor. The osmotic environment around the seeds is known to be important for germination inhibition, as is the production of endogenous abscisic acid (Berry and Bewley, 1992). In commercial seed production, seeds must be clean and dry for long-term storage. Fermentation of the seed pulp mix for 2 to 4 days is used to separate the seeds from the surrounding gel, then the seeds are washed and dried (McCormack. J, 2004).

30. Tomato seeds do not display strong dormancy, generally germinating whenever conditions (moisture and temperature) are suitable (Foolad et al., 2007). Seeds can remain viable for well over 10 years if stored under cool, dry conditions (Guadalupe et al., 2022) but lose viability rapidly in hot and humid conditions (Ariyarathna et al., 2020).

3.3 Phenotypic characteristics

31. Modern tomatoes display a wide range of phenotypic characteristics, including plant size, growth habit, fruit size, and fruit colour.

32. The two main growth habits of tomato plants are determinate or indeterminate. Determinate varieties display bushy growth, growing to approximately 1 m in height and flowering and setting fruit in a shorter time. This more concentrated harvest makes determinate varieties popular for processing as there are many ripe tomatoes at one time. In contrast, indeterminate varieties continue to grow, flower and fruit over a much longer time, potentially reaching over 5 m in height when fully mature and giving a harvest window of approximately 12 to 20 weeks (Fullelove et al., 1998). One of the largest indeterminate tomato varieties is Giant Tree, which can reach up to 6 m in height (e.g. [Seeds of Plenty](#)). Because of their size, indeterminate tomatoes are more suited to commercial cultivation in greenhouses, where the plants are usually pruned to a single stem and trained up twine connected to overhead wiring.

33. In contrast to wild tomatoes which produce small, round fruit, modern tomatoes display a wide variety in fruit size and shape. On the smaller end of fruit size are cherry tomatoes and the larger end are beefsteak-style tomatoes which can reach over 1 kg per fruit. Shapes range from round, elongated, oblate (flattened at the poles), to pear shaped (reviewed in Tanksley, 2004).

34. Tomato fruit contain different classes of plant pigments, including carotenoids (typically red, orange or yellow), such as lycopene and β -carotene, chlorophyll (usually green) and anthocyanins (red, purple or blue) which result in a range of fruit colours from red, orange, yellow, green to purple (Li et al., 2025). Anthocyanins are discussed further in Section 4.1.

3.4 Toxicity and allergenicity of tomatoes

3.4.1 Toxicity

35. Plants in the Solanaceae family produce several alkaloids, which act as defence molecules to deter pests and pathogens. Glycoalkaloids inhibit cholinesterase and if enough is consumed can cause gastrointestinal symptoms, haemolysis, and kidney inflammation in people (Novak and Haslberger, 2000). The green tissues of tomatoes are listed in a report on harmful garden plants in Western Australia (Department of Agriculture and Food Western Australia, 2005). This report classifies green tomato tissues as an irritant when eaten and harmful to stock and other animals, presumably due to alkaloid concentrations. The American Society for the Prevention of Cruelty to Animals (ASPCA) lists tomato plants as toxic to dogs, cats and horses ([ASPCA Toxic and Non-Toxic Plants List](#), accessed 10 July 2025). Clinical signs of toxicity are listed as hypersalivation, inappetence, severe gastrointestinal upset, depression, weakness, dilated pupils, and slow heart rate.

36. The main alkaloid in tomatoes is tomatine, a mixture of α -tomatine and dehydrotomatine. Dehydrotomatine contributes less than 10-20% of total tomatine in tomatoes, depending on the tissue type, therefore the following information focuses on α -tomatine. α -tomatine is present in all parts of the tomato plant but is predominately found in flowers (1100 mg/kg), leaves (975 mg/kg) and developing fruit (465 mg/kg), with levels decreasing significantly in the fruit during ripening (Friedman, 2004; Kozukue et al., 2004; Novak and Haslberger, 2000). Senescent leaves contain the highest levels at 4900 mg/kg (Friedman, 2004).

37. Modern tomato fruit have between negligible to 23 mg α -tomatine/kg fresh weight, typically about 1 mg/kg (OECD, 2008), however wild tomatoes growing in Peru have a much higher α -tomatine concentration of 500–5000 mg/kg of dry weight (approximately 30-300 mg/kg of fresh weight) and appear to be consumed by people with no ill effects (Rick et al., 1994).

38. In a laboratory study in hamsters, a diet of up to 20 mg α -tomatine/day for 21 days did not affect body weight gain or liver weight. The majority of the tomatine consumed was passed in the faeces as an insoluble complex with cholesterol, indicating that negligible tomatine was absorbed in the gastrointestinal tract (Friedman et al., 2000).

3.4.2 Allergenicity

39. The prevalence of tomato fruit allergy averages approximately 4.91% across Europe (Burney et al., 2014). There is limited information on the prevalence of tomato allergy in Australia. Tomato allergy appears to be relatively uncommon in Australia, as it is not one of the top 10 food allergies, which account for approximately 90% of all food allergies, namely allergies to wheat, peanuts, tree nuts, shellfish, eggs, milk, fish, soy, sesame and lupin ([Australian Institute of Food Safety blog](#), accessed 25 June 2025).

40. A group of tomato proteins known as Sola I are known to cause allergic reactions in some individuals. These include profilin Sola I 1, beta-fructofuranosidase Sola I 2, pathogenesis-related protein 10 (PR-10) Sola I 4, cyclophilin Sola I 5, and lipid transfer proteins Sola I 3, Sola I 6, and Sola I 7 ([WHO/IUIS Allergen Nomenclature database](#), accessed 23 June 2025).

41. Oral allergy syndrome, where people with allergies to grass or tree pollens also have a rapid reaction in the lips, mouth, tongue and throat to certain foods, is known to occur with tomatoes (Kondo and Urisu, 2009). For example, tomato Sola I 4 is structurally homologous to major birch pollen allergen Bet v 1 (Wangorsch et al., 2015), as is tomato Sola I 1 to birch pollen profilin Bet v 2 (Westphal et al., 2004). The Australasian Society of Clinical Immunology and Allergy recommends avoiding oral allergy syndrome trigger foods in their raw, uncooked forms (ASCIA, 2024). Processing tomatoes may destroy the proteins that are responsible for oral allergy syndrome, although some of these proteins are resistant to processing (reviewed in Włodarczyk et al., 2022).

42. “True” tomato allergy, i.e. not coming from a pollen cross reaction, is relatively rare. In a European allergy study, it was estimated that true tomato allergy occurs in 0.52% of the population (Burney et al., 2014).

43. Allergen levels have been shown to vary dependent on the tomato cultivar. Across 23 different tomato varieties Sola I 4 levels ranged from 0.24 and 1.71 μ g/g fresh weight tomato fruit, a more than 7-fold difference (Kurze et al., 2018). This same study also noted differences in Sol I 4 levels when comparing processing techniques and seasonal differences across years.

44. There is limited literature on allergenicity of the vegetative tissue of the tomato plant. Some limited cases of contact dermatitis have been reported in people exposed to tomato plants or tomato plant extract (Paulsen et al., 2012).

3.5 Weed risk potential for tomato plants outside cultivation

45. Tomato is not recognised as a weed in Australia ([Weeds Australia](#), accessed 3 July 2025).

46. Tomatoes are sensitive to extremes in abiotic conditions, including temperature and moisture (discussed further in Section 5.1) and susceptible to a variety of fungal, viral and bacterial diseases (discussed further in Section 5.2).

47. Tomatoes are heavy feeders that require high levels of nutrients for good growth, flowering and fruiting, including nitrogen, potassium, magnesium and calcium (Sainju et al., 2003). Competition for nutrients is one of the reasons that tomatoes are poor competitors with agricultural weeds, particularly during the early stages of tomato growth (Laude, 2023).

48. Tomatoes are considered to be herbicide-sensitive plants, including to 2,4-D, dicamba, glyphosate, saflufenacil, oxyfluorfen, and isoxaflutole, particularly from herbicide drift (Medeiros et al 2023).

49. Tomato seeds are not expected to survive the commercial composting process. In a laboratory experiment, commercial composting was simulated by adding tomato seeds to a fermenter system primed with pre-digested organic waste (Ryckeboer et al., 2002). After 1 day, tomato seeds had 0 – 0.2% viability.

Anecdotally, tomato seeds can germinate in a home garden setting either when added to compost or from dropped fruit where tomatoes have been grown (see further discussion in Section 5.3.2).

50. Limited information is available on the potential for animals to disperse tomato seeds. Tomato seeds have no specific adaptations, such as hooks or burrs to facilitate their spread on the fur or feathers of animals. As producing fruit is an important mechanism by which plants can have their seeds dispersed following consumption by animals, it is expected that tomato seeds could be dispersed via fruit eating animals. Anecdotally, it is well known that tomato fruit are attractive food to animals such as birds, rats and possums ([Birdlife Australia – a guide to feeding wild birds, Urban Food Garden – Protecting your crop at harvest time](#), accessed 17 July 2025). Tomatoes have a tough seed coat which resists digestion. Intact tomato seeds have been extracted from human stomach contents (Lee et al., 2006) and after passing through the digestive system (Lee et al., 2005), however viability was not determined. In a study of seed dispersal by serrated tortoises, tomato seeds that had passed through the digestive tract of the tortoises had higher seed germination percentage (80%), than seeds that were mechanically extracted (55%) (Setlalekgomo and Sesinyi, 2014). In a nutrient availability trial, sheep fed whole, dried tomato seeds did not have any noticeable whole tomato seeds in their faeces, only parts of the seed coat (Heguy et al., 2015), although this may be more due to thorough chewing of the seeds rather than breakdown in the digestive processes.

Section 4 The GMO, nature and effect of the genetic modification

51. The applicant proposes to release plants derived from one GM tomato event² modified for purple fruit colour, Del/Ros1-N. The GMO is known commercially as The Purple Tomato or by the OECD unique identifier NPS-01201-8. In this document, the GMO may also be referred to as the GM Purple Tomato as non-GM purple tomatoes are also discussed.

4.1 The genetic modifications in the GMO proposed for release

52. The GM Purple Tomato proposed for release has been genetically modified by the introduction of 2 transcription factors from garden snapdragon that switch on anthocyanin production during fruit ripening, resulting in purple fruit colour. The GMO also contains a selectable marker gene that confers antibiotic resistance (Table 2).

Table 2. Introduced genetic elements in the GM Purple Tomato

Gene (source)	Promoter (source)	Terminator (source)	Encoded protein	Intended function
<i>Delila</i> (<i>Antirrhinum majus</i>)	E8 promoter (<i>Solanum lycopersicum</i>) – activated during fruit ripening	Cauliflower mosaic virus (CMV) terminator (CMV)	Delila	Transcription factor – anthocyanin biosynthesis
<i>Rosea1</i> (<i>Antirrhinum majus</i>)	E8 promoter (<i>Solanum lycopersicum</i>) – activated during fruit ripening	CMV terminator (CMV)	Rosea	Transcription factor – anthocyanin biosynthesis

² An **event** is when DNA is inserted into the plant genome as a result of a single transformation process. Each time the transformation process occurs it is a new event, even if the same plasmid is used. The DNA may be inserted at a different location in the plant genome in a new event.

Gene (source)	Promoter (source)	Terminator (source)	Encoded protein	Intended function
<i>Neomycin phosphotransferase type II (nptII) gene (Escherichia coli)</i>	Nopaline synthase (NOS) promoter (<i>Agrobacterium tumefaciens</i>)	Octopine synthase 3 (Ocs 3) terminator (<i>Agrobacterium tumefaciens</i>)	Neomycin phosphotransferase type II (NPTII)	Antibiotic resistance, selectable marker

4.1.1 Introduced genes for anthocyanin production

53. The purpose of the 2 introduced genes *Delila* and *Rosea1* is to switch on anthocyanin production during fruit ripening, resulting in purple-coloured fruit, both in the skin and the flesh (Figure 3). The 2 genes are contained on the same DNA insert, and each have their own promoter and terminator.



Figure 3. Cross section of the GM Purple Tomato fruit

Source: image supplied by applicant. GMO in the MoneyMaker x Goldkrone background.

54. In the GMO, *Delila* and *Rosea1* cooperate to activate the existing anthocyanin biosynthesis pathway that is present in modern tomatoes but usually switched off (Figure 4).

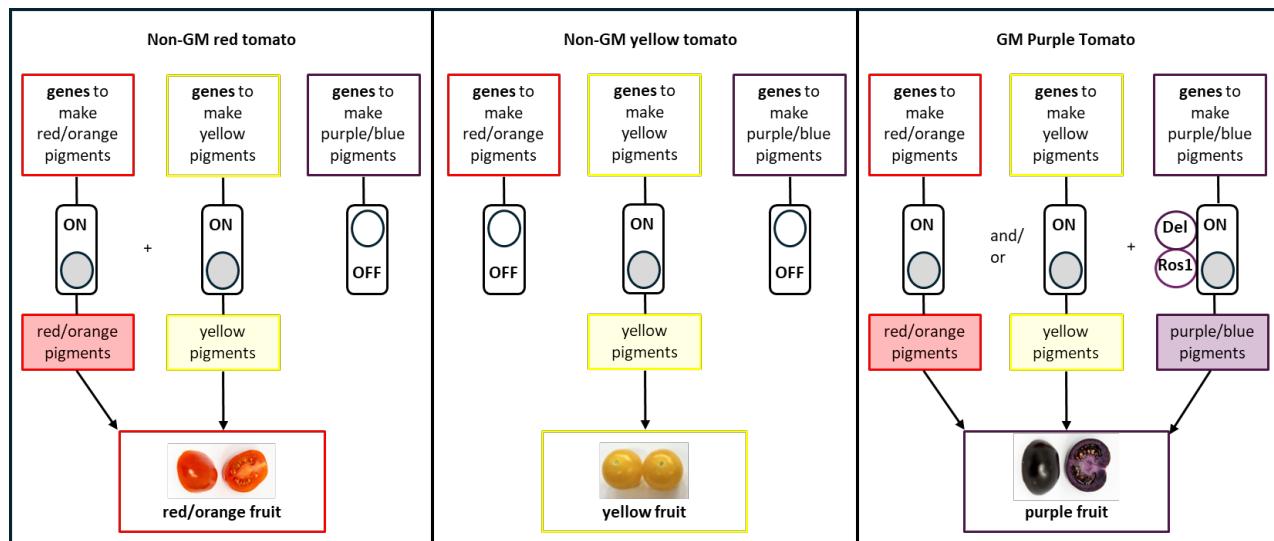


Figure 4. Comparison of pigment production in non-GM red tomatoes, non-GM yellow tomatoes and the GM Purple Tomato

Sources: Red/orange fruit and GM Purple Tomato fruit image provided by applicant. Yellow tomato fruit image from Martin and Butelli (2025).

4.1.1.1 Anthocyanin biosynthesis and function in plants

55. Anthocyanins (from the Greek *anthos* for flower and *kyáneos* for blue) are water soluble plant pigments that give red, blue, and purple colouring to plants, predominately their flowers and fruit. The colour of some anthocyanins is pH dependent, appearing red at lower pH, purple or violet at neutral pH, and blue at higher pH (reviewed in Glover and Martin, 2012; Khoo et al., 2017). Blue colouring is influenced by aromatic acylation and intense blue colouring can result from the association of anthocyanins with metals such as aluminium or iron (Glover and Martin, 2012; Takeda, 2006; Wahyuningsih et al., 2017).

56. The production of anthocyanins is regulated in response to a number of factors, including growth hormones, light, temperature, and nutrient availability (reviewed in Kapoor et al., 2022). Anthocyanins have a range of important functions in plants, including attracting pollinators through colouration of flowers (Glover and Martin, 2012), providing protection from the effects of high light conditions, whether through light-absorbing capacity or through antioxidant activity (Zhao et al., 2022; Zheng et al., 2021), and protecting against abiotic stresses such as cold stress (Xu et al., 2017) and drought stress (Cirillo et al., 2021). Anthocyanins have strong antioxidant activity, reducing reactive oxygen species (ROS) and oxidative stress in plants (reviewed in Martín et al., 2017).

57. Although the most striking accumulation of anthocyanins is in flowers and fruit, anthocyanins also accumulate transiently in vegetative tissues in response to external stimuli such as light, cold and osmotic stress, and then are degraded when no longer needed (Hughes et al., 2007).

58. The non-sugar bound form of anthocyanins are known as anthocyanidins. The 6 most common anthocyanidins in plants are pelargonidin, cyanidin, delphinidin, petunidin, peonidin, and malvidin. Anthocyanidins are not stable and are readily converted to a sugar bound form, then stored in vacuoles (reviewed in Goncalves et al., 2021).

59. The anthocyanin biosynthesis pathway is well studied and is known to be conserved across different plant species. Anthocyanin biosynthesis is part of the phenylpropanoid pathway, which begins with the amino acid phenylalanine and produces several critical metabolites for plant growth, development, defence, and stress responses, including flavonoids, coumarins and lignins. The flavonoid biosynthesis pathway, which produces molecules such as anthocyanins, flavones, and flavonols, splits out from the phenylpropanoid pathway at the 4-coumaryl-CoA step. The genes encoding the enzymes involved in the anthocyanin biosynthesis pathway can be categorised into two groups; early biosynthetic genes which are also involved in the synthesis of flavonols and other flavonoid compounds (e.g. chalcone synthase; CHS, chalcone isomerase; CHI, flavanone 3-hydroxylase; F3H) and late biosynthetic genes which are involved in the downstream production of anthocyanins (e.g. dihydroflavonol-4 reductase; DFR, anthocyanidin synthase; ANS, UDP-glucose: flavonoid-3-O-glucosyltransferase; UFGT)(reviewed in Khusnutdinov et al., 2021)(Figure 5).

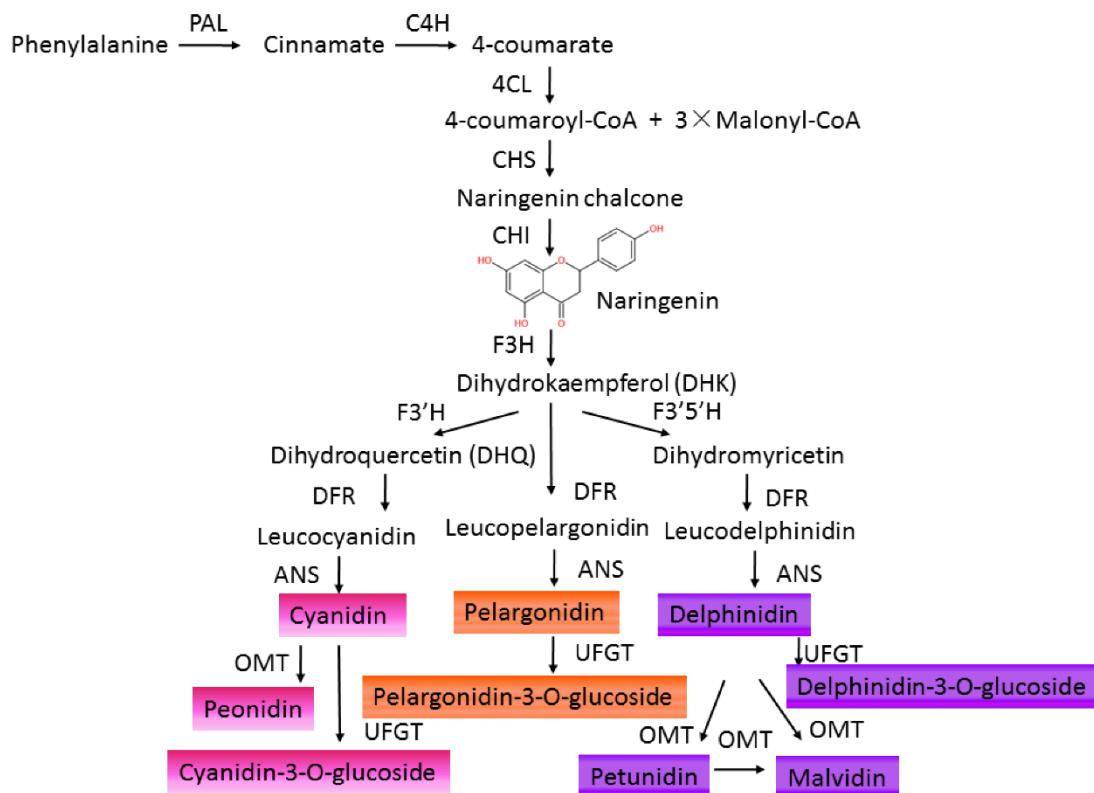


Figure 5. Anthocyanin biosynthesis pathway in plants

Source: Ma et al. (2021). PAL, phenylalanine ammonia lyase; C4H, cinnamate 4-hydroxylase; 4CL, 4-coumarate CoA ligase; CHS, chalcone synthase; CHI, chalcone isomerase; F3H, flavanone 3-hydroxylase; F3'H, flavonoid 30 hydroxylase; F3'5'H, flavonoid 3050hydroxylase; FLS, flavonol synthase; DFR, dihydroflavonol 4-reductase; ANS, anthocyanidin synthase; UFGT, UDP-galactose flavonoid 3-O-galactosyltransferase; OMT, O-methyl transferase.

60. Across many plant species, anthocyanin biosynthesis is activated by an MBW regulatory complex consisting of 3 types of transcription factors (reviewed in Cappellini et al., 2021):

- R2R3-MYB
- basic helix-loop-helix (bHLH) and
- tryptophan-aspartic acid (WDR)-type proteins.

61. WDR genes are constitutively expressed in many plants (de Vetten et al., 1997; Walker et al., 1999), and therefore levels of the MYB and bHLH transcription factors are important for activating anthocyanin biosynthesis.

4.1.1.2 Regulation of anthocyanin biosynthesis in tomatoes

62. While modern tomatoes with red, orange and yellow fruit contain genes encoding the enzymes responsible for the anthocyanin biosynthesis pathway, activation of the pathway is incomplete in fruit. Anthocyanin biosynthesis is only normally activated in some vegetative tissues like the hypocotyl (the embryonic stem in a young seedling) in response to stress conditions, specifically derivatives of delphinidin, petunidin and malvidin (Roldan et al., 2014).

63. In tomatoes, anthocyanin biosynthesis is regulated by MYB transcription factors such as AN2, ANT1, ANT1-like, and AN2-like/Aft, bHLH transcription factors JAF13 and AN1, and the WDR transcription factor AN11 (reviewed in Menconi et al., 2024)(Figure 6). The transcription factors have different roles in activating anthocyanin biosynthesis in different tomato tissues. For example, the bHLH transcription factor AN1 (also known as Hoffman's anthocyaninless) has been shown to play an important role in accumulation of anthocyanin in young tomato seedlings in response to low temperatures (Qiu et al., 2016) and, in combination with AN11 and AN2, in fruit and vegetative tissues in response to high light conditions (Zhang et al., 2019). Overexpression of the MYB transcription factor ANT1 in MicroTom tomatoes resulted in purple-tinged areas in the leaves, stems and flowers, and purple spots on the skin of the fruit due to

accumulation of anthocyanins, specifically derivatives of delphinidin, petunidin and malvidin (Mathews et al., 2003). In this same study, a purple leaf phenotype was also observed when tobacco was engineered to overexpress ANT1.

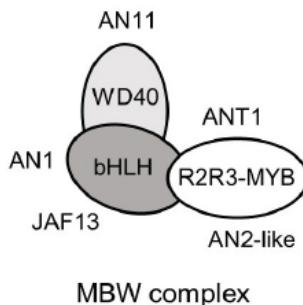


Figure 6. Anthocyanin biosynthetic regulatory genes in tomato

Source: Teo et al. (2022).

64. Some wild relatives of tomato have fruit with purple skin and have been crossed with domesticated non-GM tomatoes to give the non-GM purple fruit skin trait. Analysis of these wild relatives and their hybrids with modern tomatoes has revealed much about the regulation of anthocyanin biosynthesis in tomatoes. Three loci have been described that are derived from wild tomato and are responsible for increased anthocyanin production and purple colour in non-GM purple tomatoes (Mes et al., 2008).

65. The first is the *Aft* locus, which includes a gene that encodes the R2R3-MYB transcription factor, AN2-like (Sun et al., 2020; Yan et al., 2020). AN2-like contributes to the purple fruit skin colouring in the non-GM Indigo Rose tomato and is derived from a crossing of modern tomato with the wild tomato relative *S. chilense*. Mutations in this gene in modern tomato varieties have led to splicing defects and loss of function in activating anthocyanin biosynthesis. In Indigo Rose tomatoes, functional AN2-like activates the accumulation of anthocyanins in the skin of the fruit in a light-dependent manner. When the *AN2-like* gene was added to red-fruited variety Ailsa Craig under the control of the tomato E8 fruit-ripening specific promoter, anthocyanins accumulated in both the skin and flesh of the fruit during ripening. Anthocyanin levels were 222 mg/100 g fresh fruit weight in the modified purple tomato compared to undetectable in the control (Sun et al., 2020).

66. The second locus is *atv*, also found in the Indigo Rose variety, which contains the gene *MYBATV* derived from *S. cheesmaniae*. *MYBATV* encodes a MYB transcription factor that is a negative regulator of anthocyanin biosynthesis in most modern cultivars and wild tomatoes, however *S. cheesmaniae* and Indigo Rose contain a mutated version that is non-functional (Sun et al., 2020).

67. The third locus is *Aubergine* (*Abg*), which is derived from a spontaneous cross with *S. lycopersicoides*. Fruit of heterozygous *Abg*-containing plants displays a blotchy purple colouring in response to light, as well as accumulating anthocyanins in the leaves and stem. Homozygous *Abg* plants fail to thrive and are sterile. It has been recently proposed that *Abg* is a splicing variant of AN2-like (Menconi et al., 2023).

4.1.1.3 Delila and Rosea1

68. Delila is a bHLH transcription factor that regulates anthocyanin biosynthesis in *A. majus*. *A. majus* with a loss of function *Delila* mutant displayed a loss of anthocyanin pigment in the tube of the flower, thought to be due to lack of activation of the later stage of the anthocyanin biosynthesis pathway (Martin et al., 1991). Further studies in snapdragon have indicated that Delila upregulates expression of an anthocyanin pathway late biosynthetic gene encoding the enzyme DFR (Albert et al., 2021).

69. Rosea1 is a MYB transcription factor that regulates anthocyanin biosynthesis in *A. majus*. In *A. majus*, Rosea1 has been shown to upregulate transcription of late biosynthetic genes for anthocyanin

production, as well as an anthocyanin transporter and a gene involved in flavanol synthesis. *Rosea1* had no effect on the expression of the early biosynthetic gene *CHS* and a minor effect on *CHI* (Schwinn et al., 2006).

70. Overexpression of either snapdragon *Rosea1* (Naing et al., 2018) or snapdragon *Delila* (Naing et al., 2017) alone throughout entire tobacco plants increased the production of anthocyanins, reduced reactive oxygen species, and increased tolerance to abiotic stresses such as cold, drought and salt tolerance.

71. MBW complexes have also been shown to play a role in cell differentiation processes like root hair and trichome differentiation. When *Rosea1* and *Delila* were engineered into tomatoes under the control of a dexamethasone-inducible promoter, purple colouring was observed in vegetative tissues like the roots, stems and leaves, but not fruit or flowers (Outchkourov et al., 2018). Changes were also observed in root branching, root epithelial cell morphology, seed germination, and leaf conductance.

4.1.1.4 Comparison of non-GM purple tomatoes and the GM Purple Tomato

72. The purple fruit colour trait has also been achieved in tomatoes that have been conventionally bred (non-GM).

73. Some species of wild tomatoes have fruit with purple skin when exposed to light and this trait has been conventionally crossed into modern tomatoes. As discussed in Section 4.1.1.2, the non-GM variety Indigo Rose contains the *AN2-like* gene from *S. chilense*, encoding a positive regulator of anthocyanin biosynthesis that is non-functional in modern tomatoes, and *MYBATV* from *S. cheesmaniae*, encoding a repressor of anthocyanin biosynthesis that is non-functional in Indigo Rose and functional in modern tomato varieties. Indigo Rose fruit show light-dependent accumulation of petunidin, malvidin and delphinidin in the skin, but not in the flesh (Mes et al., 2008; Sun et al., 2020). Another purple-skinned non-GM variety that contains the same anthocyanin-related genes as Indigo Rose is called Sun Black (Mazzucato et al., 2013).

74. Purple fruit colouring that is not due to anthocyanins has also been found in tomatoes with various mutations in the *green flesh* gene. Mutations in this gene prevent chlorophyll from being degraded during fruit ripening, but there is still the normal accumulation of carotenoids (Cheung et al., 1993). This results in ripe fruit which have muddy purple or brown skin and may also have a darker tinge to the flesh, and includes varieties such as Cherokee Purple, Black Cherry, and Purple Russian (Barry and Pandey, 2009).

75. While these non-GM purple tomato varieties have purple skin, none of them have all purple flesh. This means they can be easily distinguished from the GM Purple Tomato which has all purple skin and flesh.

Pigments in fruit	GM Purple Tomato	Indigo Rose (non-GM)	Cherokee Purple (non-GM)
Chlorophyll	low/not present	low/not present	present
Red/orange and/or yellow pigments	present	present	present
Anthocyanins (skin)	present	present	low/not present
Anthocyanins (flesh)	present	low/not present	low/not present

Figure 7. Pigments in the ripe fruit of the GM Purple Tomato and non-GM purple tomatoes Indigo Rose and Cherokee Purple

Source: GM Purple Tomato image supplied by applicant. Indigo Rose image from [Territorial Seed Company](#). Cherokee Purple image from [Seeds of Plenty](#).

4.1.2 Selectable marker - *nptII*

76. The introduced *nptII* gene was used as a selectable marker during early stages of development. The *nptII* gene is derived from *Escherichia coli* strain K12 and encodes an enzyme, neomycin phosphotransferase (NPTII), also known as aminoglycoside 3'-phosphotransferase II enzyme (APH(3')-IIa). It provides resistance to neomycin, kanamycin, paromomycin and related aminoglycoside antibiotics by using ATP to phosphorylate and inactivate the antibiotic, preventing it from killing NPTII producing cells. More information on *nptII*, including information regarding its lack of toxicity or allergenicity, is available in the document *Risk Assessment Reference: Marker Genes in GM Plants* on the [Risk assessment reference documents](#) page on the OGTR website.

4.1.3 Regulatory sequences

77. Short regulatory sequences that control expression of the genes are also present in the GMO (Table 2). Expression of the *Delila* and *Rosea1* genes is driven by the tomato E8 promoter. The E8 promoter is a tissue specific promoter, which is active during fruit ripening, but not in unripe fruit or vegetative tissues (Hirai et al., 2011; Kurokawa et al., 2013). The *E8* gene encodes an enzyme involved in the detoxification of the glycoalkaloid α -tomatine to esculenoside A, which occurs during fruit ripening (Akiyama et al., 2021). The E8 promoter responds to ethylene, a gaseous plant hormone that initiates fruit ripening (Deikman et al., 1992). Expression of the *nptII* gene is driven by a constitutive NOS promoter from *Agrobacterium tumefaciens* which is active in a wide range of plant tissues and developmental stages (Ebert et al., 1987). Other short regulatory elements used include termination sequences.

4.2 Method of genetic modification

78. The GMO was generated by *Agrobacterium*-mediated transformation of the parental tomato variety MicroTom, a determinate dwarf cherry tomato. *Agrobacterium tumefaciens* is a species of soil bacteria that naturally infects plants and transfers some of its DNA, known as transfer DNA or T-DNA, into the plant during the infection process. By using molecular biology techniques to place genes of interest within this T-DNA, *Agrobacteria* can be used to transfer these genes into a plant. More information about this method can be found in the document *Methods of plant genetic modification*, available from the [OGTR Risk Assessment References](#) page.

79. After transformation, kanamycin was used to select for GM tomato cells. The resulting material was tested and confirmed to be free from *Agrobacteria*.

4.3 Toxicity and allergenicity of the proteins associated with the introduced genes

80. The introduced *Delila* and *Rosea1* genes are derived from *A. majus*, more commonly known as garden snapdragon. A comprehensive search of the literature yielded no information to suggest that either of the encoded proteins are toxic or allergenic to people, or toxic to other organisms. Snapdragon flowers are edible for humans (Chensom et al., 2019) and are considered non-toxic for animals, including dogs, cats and horses ([ASPCA Toxic and Non-Toxic Plants List](#), accessed 10 July 2025).

81. The applicant has reported that bioinformatic analysis showed no amino acid sequence similarity of Delila or Rosea1 to known allergens or toxins (Martin and Butelli, 2025). The levels of the Delila and Rosea1 proteins were below the limit of detection in juice from the GM fruit (<0.5 ng Delila and <0.2 ng Rosea1 protein per mL juice). As the levels of Delila and Rosea1 were very low in the GM Purple Tomato fruit, the applicant expressed the proteins in *E. coli* to purify enough protein for proteolytic digestion analysis. Both *E. coli*-derived proteins were rapidly degraded by pepsin in simulated gastric fluid, indicating the proteins would be rapidly degraded in the digestive system if consumed.

82. There is no evidence that the *nptII* gene or the protein it encodes is toxic or allergenic ([OGTR Risk Assessment document](#) and references therein). GM foods containing the *nptII* gene have been assessed and approved for sale in Australia ([FSANZ website](#), accessed 30 June 2025).

4.4 Toxicity and allergenicity of the end products associated with the introduced genes

83. Anthocyanin-containing foods are consumed by people around the world, with average daily intakes depending on many factors, including dietary patterns and food availability. In a US study of dietary flavonoid intake, it was estimated that daily average intake of anthocyanins was 11.6 mg/day, with berries contributing the most to anthocyanin consumption (Sebastian et al., 2015). The Australian intake of anthocyanins is estimated to be even higher at 24.17 mg/day, again with berries as the top source of anthocyanins (Igwe et al., 2019). In a clinical study of oxidative stress and inflammation, no adverse effects were reported when participants were given a blackcurrant extract daily containing approximately 240 mg/day anthocyanins for a 5 week period, predominately derivatives of delphinidin and cyanidin (Hurst et al., 2020).

84. The anthocyanin concentrations in the various GM tomato breeding varieties are 39.5 – 283.5 mg/100 g fresh fruit weight (discussed further in Section 4.5.4), which are within the ranges of total anthocyanins seen in common anthocyanin-containing foods such as blackberries, blueberries, black currant, elderberry and red cabbage (Table 3). In particular, blueberries and blackcurrants are specifically enriched in delphinidin and petunidin, which are the primary anthocyanidins found in the GMO. This indicates that people regularly consume food containing the same pigments produced in the GMO.

Table 3. Anthocyanin concentrations in common foods

Food	mg/100 g (of fresh weight or form consumed)			Total ACN/serving ^a (mg)
	Delphinidin	Petunidin	Total ACN	
<i>Fruit</i>				
Blackberry	-	-	245	353
Marion blackberry	-	-	300.5	433
Blueberry (cultivated)	120.7	71.9	386.6	529
Blueberry (wild)	141.1	87.6	486.5	705
Chokeberry	-	-	1480	2147
Black currant	333	7.3	476	533
Elderberry	-	-	1375	1993
Black raspberry	-	-	687	845
<i>Vegetables</i>				
Black bean	18.5	15.4	44.5	23.1
Eggplant	85.7	-	85.7	35.1
Red cabbage	-	-	322	113
Red onion	-	-	48.5	38.8
Red radish	-	-	100.1	116

Adapted from Wu et al. (2006). Select fruits and vegetables with the highest anthocyanin concentrations in each category are shown. The main 6 anthocyanidins were measured, only individual values for delphinidin and petunidin are shown here. ^a Serving size from the USDA National Nutrient Database for Standard Reference. ACN = anthocyanins.

85. Oral bioavailability of anthocyanins is low, estimated to be 0.26-1.8% in animal studies (reviewed in Fang, 2014).

86. Anthocyanins are not generally considered to be toxic, and are used as a dye and food colourant (reviewed in Khoo et al., 2017).

87. Anthocyanins are not generally considered to be allergenic, however there are some limited reports of hypersensitivity reactions and allergies when people are exposed dermally to concentrated anthocyanins (reviewed in Lis and Bartuzi, 2023). For example, when nasunin from eggplant extract was used at over 5% concentration in a skin patch test, 12% of participants experienced a moderate skin reaction and 3% experienced an allergic reaction. However, the concentration of this pigment does not normally exceed 1% as a dye in foods and cosmetics (Gallo et al., 2014).

4.5 Characterisation of the GMO

4.5.1 Breeding background of the GMO

88. Four primary transformants (C, N, Y, Z) were generated via Agrobacterium-mediated transformation of MicroTom tissue (Figure 8). The N transformant was selected for further development due to having the highest anthocyanin production in the fruit (Butelli et al., 2008). This transformant was self-pollinated for 6 generations (T6) to create the “Del/Ros1-N in MicroTom” variety. One individual plant in the T1 generation of the MicroTom variety was crossed to MoneyMaker (an indeterminate variety with medium sized fruit) to generate a purple fruited F1 population. One of the F1 plants was self-pollinated and then a F2 plant with dark purple fruit was self-pollinated through 8 generations propagated by single seed descent to develop the variety “Del/Ros1-N in MoneyMaker”.

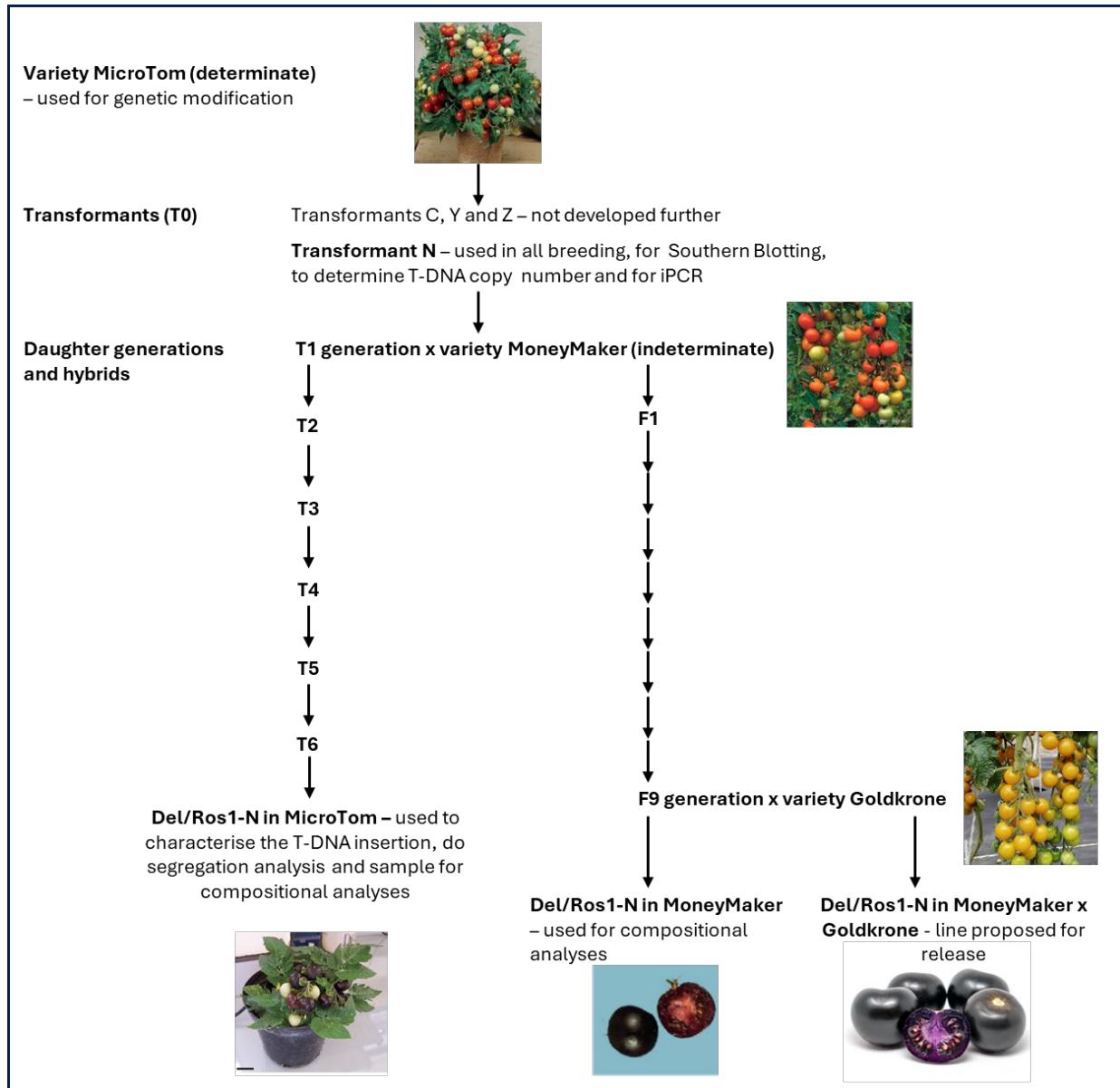


Figure 8. Breeding strategy of the GMO in the MicroTom, MoneyMaker and Goldkrone backgrounds

Source: adapted from diagram supplied by applicant. MicroTom image from [Pan American Seeds](#). MoneyMaker image from [Vasili's](#). Goldkrone image from [Easyseeds](#). Del/Ros1-N in MicroTom image from Butelli et al. (2008). Del/Ros1-N in MoneyMaker image from Martin and Butelli (2025). Del/Ros1-N in MoneyMaker x Goldkrone image from applicant.

89. The commercial breeding variety released in the US is derived from MoneyMaker F9 x Goldkrone, an indeterminate cherry tomato variety with yellow fruit. This cross was chosen for commercial development as the combination of yellow pigments with the purple/blue anthocyanins results in a darker purple trait

compared to crosses with red tomatoes, and the fruit was reportedly sweeter (Martin and Butelli, 2025). This is also the variety proposed for release in Australia.

90. Other successful crosses of the GMO resulting in purple fruit included to Ohio 8243, a processing tomato variety that is used for products such as tomato juice, Ailsa Craig, Maglia Rose, and Lucinda (Martin and Butelli, 2025).

4.5.2 Molecular characterisation

91. Southern blot analysis of the original N transformant in MicroTom revealed 2 inserts of the transfer DNA (T-DNA) containing the genes of interest; one at “Locus A” and one at “Locus B”. Inverse polymerase chain reaction (iPCR) was used to identify the sequences flanking the left and right borders of the T-DNA. During subsequent breeding of the 2 varieties, the insert at Locus A was lost through segregation. This was confirmed by polymerase chain reaction (PCR) analysis of the relevant regions of Locus A and Locus B in T6 Del/Ros1-N in MicroTom plants and also in Del/Ros1-N in MoneyMaker self-pollinated for 9 generations (F9). The insert at Locus B was confirmed to be present in both varieties.

92. iPCR and whole genome sequencing of both MicroTom and MoneyMaker varieties confirmed that the Locus B T-DNA insert was located at position 62904771 on chromosome 4 (Figure 9).

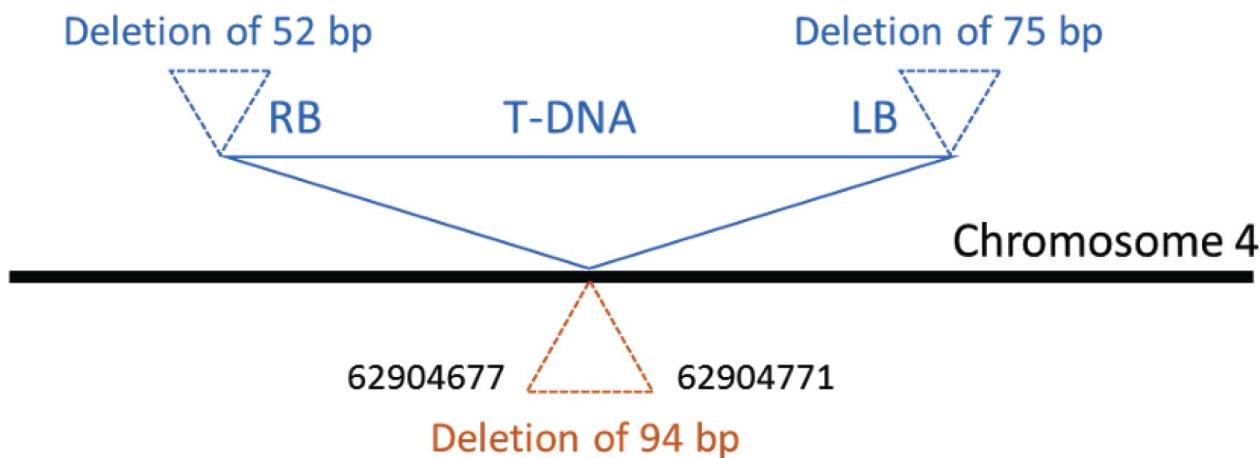


Figure 9. Location of the Locus B T-DNA insertion in the GM Purple Tomato genome

Source: image supplied by applicant. Insertion as determined by PCR analysis and confirmed by whole genome sequencing. The figure shows the relevant portion of chromosome 4 where the genes of interest have been inserted as a single T-DNA insert. Deletions that occurred as part of the insertions are shown. bp = base pairs, RB = right border of the T-DNA, LB = left border of the T-DNA.

93. Whole genome sequencing of the MicroTom and MoneyMaker x Goldkrone-derived varieties was used to confirm that all inserted genetic elements were intact in the single T-DNA insertion at Locus B. No mutations or mismatches were present, nor were any vector backbone sequences. The applicant has also stated that the insert on locus B did not interrupt any tomato genes/existing open reading frame (ORF) or create new functional ORFs.

94. In this RARMP “the GMO” refers to the event with the OECD identifier NPS-01201-8, being the N transformant containing the Del/Ros1 insert at Locus B and any varieties derived from it, including crosses with other *S. lycopersicum* cultivars. The following characterisation of the GMO includes data on Del/Ros1-N in MicroTom, Del/Ros1-N in MoneyMaker and Del/Ros1-N in MoneyMaker x Goldkrone, as indicated.

4.5.3 Inheritance and stability of the insert

95. Genotypic (presence of the *nptII* gene) and phenotypic (kanamycin resistance, colour of tomato fruit) characterisation of crosses of the GMO with non-GM tomatoes has shown that the insert is inherited in a dominant Mendelian manner.

96. As discussed in Section 4.5.2, whole genome sequencing of 2 varieties of the GMO has shown that the inserts have remained unchanged during the breeding program. In the case of the MoneyMaker x Goldkrone variety, the material used for sequencing is more than 7 generations of self-fertilised crosses from the original MoneyMaker and Goldkrone cross, and for the MicroTom variety it was more than 6 generations removed from the original N transformant, indicating stable inheritance of the insert.

97. The applicant has stated that, to date, no loss of the purple phenotype has been recorded, either in greenhouse breeding trials or in the commercial production of thousands of plants.

4.5.4 Anthocyanin content and gene expression analysis

4.5.4.1 Quantification and characterisation of anthocyanins

98. In the original hemizygous Del/Ros1-N MicroTom transformant, the anthocyanin concentration was measured at 283.5 mg/100 g of fresh fruit weight, compared to 0.8 – 1.6 mg/100 g in the MicroTom control (Butelli et al., 2008). The applicant has stated that the anthocyanin concentration in the MoneyMaker background, is 40 mg/100 g fresh weight. Literature indicates that non-GM MoneyMaker tomatoes have negligible anthocyanins (Sapir et al., 2008). In the MoneyMaker x Goldkrone variety, anthocyanin concentration ranges from 39.5 – 107.2 mg/100 g fresh fruit weight compared to none in non-GM Goldkrone (Martin and Butelli, 2025). The applicant has commented that the lower concentrations in the commercial variety are due to the higher water content in the globe-type tomatoes. The anthocyanin concentrations in the fruit of the MicroTom, MoneyMaker and MoneyMaker x Goldkrone varieties are within the ranges seen in common anthocyanin-containing foods such as blackberries, blueberries and red cabbage (Table 3). For comparison, anthocyanin concentrations in non-GM purple Indigo Rose tomatoes are 116.11 mg/100 g fresh weight skin (whole fruit was not analysed) (Mes et al., 2008).

99. Although not the subject of the current application, a study investigated further improvements to the anthocyanin content of Del/Ros1-N tomatoes. MYB12 is a transcription factor that regulates flavanol production in *Arabidopsis thaliana*, and has been shown to drastically increase flavanol content in tomato fruit under the E8 promoter, resulting in orange fruit (Luo et al., 2008). Del/Ros1 in MicroTom was crossed with AtMYB12 in MicroTom, which contains the MYB12 gene from *A. thaliana* under the control of the E8 promoter (Zhang et al., 2015). Fruit from Del/Ros1 x AtMYB12 (named Indigo) had an almost 2-fold increase in anthocyanin content compared to Del/Ros1 alone. The authors speculate that the dramatic increase in anthocyanins in the hybrid may be due to MYB12 upregulating earlier parts of the phenylpropanoid pathway, therefore increasing supply of metabolites into the anthocyanin pathway.

100. High-performance liquid chromatography (HPLC) and electrospray ionisation tandem mass spectrometry were used to analyse anthocyanin content in the flesh and peel of tomatoes from the MicroTom variety (Butelli et al., 2008). The major anthocyanins present in both the flesh and peel were:

- delphinidin 3-(cis-coumaroyl)-rutinoside-5-glucoside
- delphinidin 3-(trans-coumaroyl)-rutinoside-5-glucoside (also known as nasunin)
- delphinidin 3-(caffeooyl)-rutinoside-5-glucoside
- delphinidin 3-(feruloyl)-rutinoside-5-glucoside
- petunidin 3-(trans-coumaroyl)-rutinoside-5-glucoside (also known as petanin), and
- petunidin 3-(feruloyl)-rutinoside-5-glucoside.

101. Petanin and nasunin were the most abundant anthocyanins in the GM tomatoes and were not detected in the non-GM control fruit (Tohge et al., 2015). Petanin is also found in Indigo Rose tomato (Wang et al., 2020) and petunia (Schram et al., 1983), and nasunin is the main anthocyanin in eggplant skin (Panda et al., 2025; Sakamura et al., 1963).

102. A different laboratory used the methods described in Butelli et al. (2008) to create their own, different GM purple tomato variety (a GMO not covered in the current application) in the Rubion tomato cultivar background containing the same construct that was used to create the GM Purple Tomato (Lim et al., 2014). Anthocyanins were characterised in the ripe fruit and, like the GM Purple Tomato, petanin and nasunin were also the most abundant anthocyanins (Su et al., 2016).

103. As discussed in Section 4.1.1.1, anthocyanins are known to have strong antioxidant activity. The antioxidant activity of the GMO in the MicroTom background was 3 times higher than the control as measured by the Trolox Equivalent Antioxidant Capacity test, which determines how well a substance can neutralise free radicals in comparison to the vitamin E derivative Trolox (Butelli et al., 2008).

4.5.4.2 Expression of *Delila* and *Rosea1* and components of the anthocyanin biosynthesis pathway

104. Expression of *Delila* and *Rosea1* in the GM Purple Tomato fruit has been confirmed by multiple methods, including northern blot (Butelli et al., 2008)(Figure 10). As discussed in Chapter 1 Section 4.3, the levels of the *Delila* and *Rosea1* proteins were below the limit of detection in juice from the GM fruit (<0.5 ng *Delila* and <0.2 ng *Rosea1* protein per mL juice) (Martin and Butelli, 2025).

105. Expression of *Delila* and *Rosea1* in the GM Purple Tomato fruit lead to expression of multiple genes encoding enzymes involved in both the early and late stages of anthocyanin biosynthesis, including PAL, CHI, and F3'5'H, enzymes involved in side chain modification like a putative anthocyanin acyltransferase, and 2 genes that are expected to facilitate transport of the anthocyanins into vacuoles, putative anthocyanin permease and glutathione S-transferase (Figure 10) (Butelli et al., 2008).

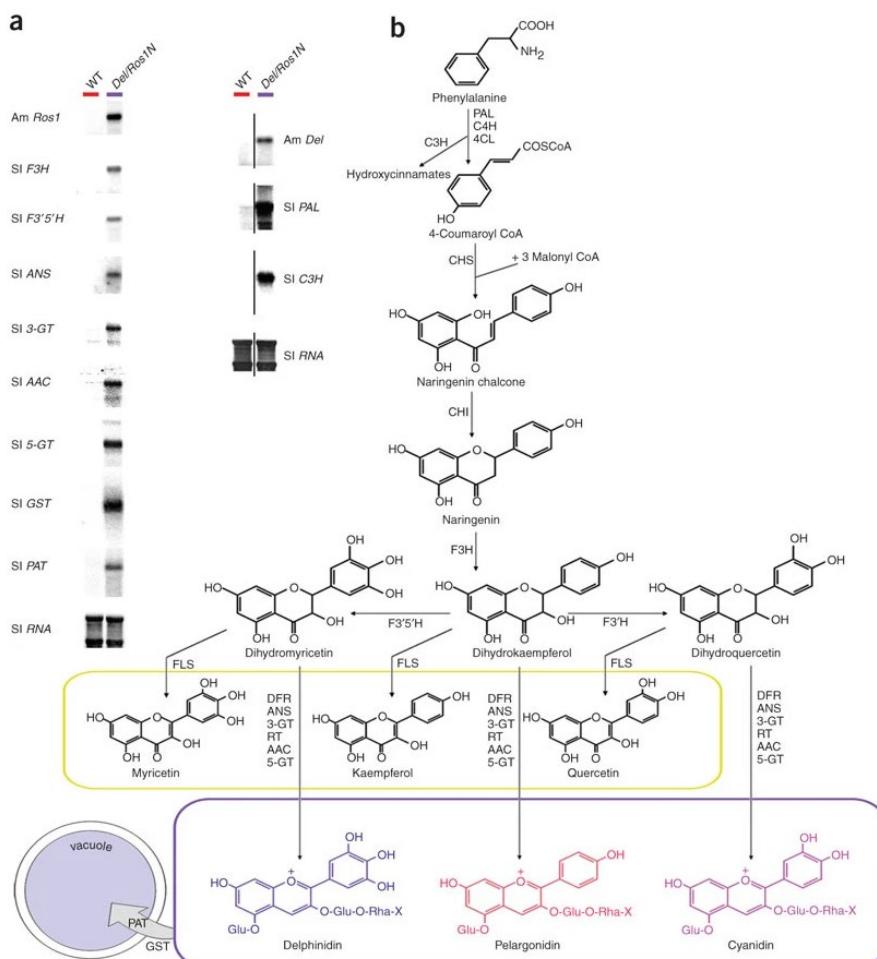


Figure 10. Anthocyanin biosynthesis genes upregulated in the GM Purple Tomato

Source: partial figure from Butelli et al. (2008). a) Northern blots showing the differential expression of several anthocyanin biosynthetic genes identified by suppression subtractive hybridisation. b) Schematic representation of the anthocyanin biosynthetic pathway. Relevant flavonoid classes are shown in boxes. Yellow box, flavonols; purple box, anthocyanins.

PAL, phenylalanine ammonia lyase; 4CL, 4-coumarate:coenzyme A ligase; C4H, cinnamate 4-hydroxylase; C3H, 4-coumarate 3-hydroxylase; CHS, chalcone synthase; CHI, chalcone isomerase; F3H, flavanone-3-hydroxylase; F3'H, flavonoid-3'-hydroxylase; F3'5'H, flavonoid-3'5'-hydroxylase; FLS, flavonol synthase; DFR, dihydroflavonol reductase; ANS, anthocyanidin synthase; 3-GT, flavonoid 3-O-glucosyltransferase; RT, flavonoid 3-O-glucoside-rhamnosyltransferase AAC, anthocyanin acyltransferase; 5-GT, flavonoid-5-glucosyltransferase; GST, glutathione S-transferase; PAT, putative anthocyanin transporter.

4.5.4.3 Other changes in the phenylpropanoid pathway

106. As Delila and Rosea1 are acting on common enzymes in the phenylpropanoid biosynthesis pathway, it is possible that other metabolites in this pathway would be increased. Increases in chlorogenic acid, flavonones and flavonols were observed in the GM Purple Tomato fruit (Tohge et al., 2015). This same study showed that pathways responsible for input into the phenylpropanoid pathway are also increased, including the shikimate pathway (essential for the synthesis of aromatic acids like phenylalanine) and phenylalanine biosynthesis.

107. Some phenylpropanoid metabolites were decreased in the GM Purple Tomato fruit, including phenylalanine. As phenylalanine is the first input to the phenylpropanoid pathway, which leads to anthocyanin biosynthesis, this decrease in phenylalanine is thought to be because of increased demands for inputs in the anthocyanin biosynthesis pathway, even outstripping the increases in phenylalanine biosynthesis (Tohge et al., 2015).

4.5.5 Uregulation of a plant defensin

108. Uregulation of expression of the endogenous *tgas118* gamma-thionin gene, which encodes a small defensin protein, was also observed in the GM Purple Tomato fruit (Butelli et al., 2008). This upregulation was further characterised at different ripeness stages with a 139-fold increase in RNA expression (13553 vs 98 count RNA reads) compared to wild-type seen in the GM tomatoes at 1 week after breaker stage, and a 285-fold increase (8289 vs 29 count RNA reads) seen at 4 weeks after breaker stage (Tohge et al., 2015). The applicant has not quantified the amount of TGAS118 defensin peptide in the GM Purple Tomato fruit, but given the increase in gene expression, it is expected that levels of TGAS118 would be increased compared to levels in the non-GM control.

109. Plant defensins are peptides that have antimicrobial activity, usually against fungi (reviewed in Stotz et al., 2009b).

110. The *tgas118* gene has been shown to be predominately expressed during tomato flower development and in non-GM tomatoes is induced by plant growth regulator gibberellin, tissue wounding and dehydration (van den Heuvel et al., 2001). TGAS118, also known as DEF1 or DF1, is predicted to be secreted from the cell and is upregulated in response to infection with soil-borne fungus *Verticillium dahliae*. The same study showed limited changes in expression after cold stress and viral infection of seedlings (Nikoloudakis et al., 2020). Another study showed that *tgas118* is expressed in the root, stem, leaf, flower and mature fruit of healthy tomato plants, predominately in the stem and mature fruit, and that it confers resistance to *Phytophthora infestans*, with overexpression of *tgas118* resulting in reduced ROS accumulation (Cui et al., 2018). Several other tomato defensins have been identified, including tomato defensin DEF2/DF2 (closely related to TGAS118/DEF1/DF1) which has been shown to have activity against fungal pathogen *Botrytis cinerea* (Stotz et al., 2009a) and fungal-like pathogen *Phytophthora infestans* (Cui et al., 2018), and tomato pistil predominant 3 defensin (TPP3) which has activity against fungus *Fusarium graminearum* (Baxter et al., 2015).

111. No direct link between anthocyanin biosynthesis and defensins could be found in the literature. It is possible that Delila and/or Rosea1 act directly to regulate expression of *tgas118*, however it is more likely that there is some complex regulatory interplay between anthocyanin biosynthesis, defensins, ROS and tomato stress responses.

112. Some defensins are known to be allergens, including those from peanut, celery, soybean and horse chestnut, and some allergenic proteins have a defensin domain, known as a defensin-polyproline-linked protein or DPLP, particularly plants from the *Artemisia* genus (Cosi and Gadermaier, 2023). TGAS118 is not

known to be allergenic ([Allergen Online database](#), [WHO/IUIS Allergen Nomenclature database](#), accessed 22 July 2025).

113. Defensins from other plants have been reported to have toxicity in mammalian cells *in vitro*, including a defensin from the shrub *Pyrularia pubera* which displayed toxicity in cultured mouse cells (Vernon et al., 1985), a defensin from barley that inhibited translation in cell free systems derived from mammalian cells (Mendez et al., 1990) and the TPP3 defensin from tomato that is cytolytic to a human lymphoma cell lines (Baxter et al., 2015). No information about the potential toxicity of TGAS118 could be found in the literature.

114. Defensins are relatively abundant in seeds, which are vulnerable to fungal infection during germination (reviewed in Stotz et al., 2009b). For example, multiple types of defensins are strongly upregulated in wheat seeds, while having low expression throughout the rest of the plant (Shi et al., 2024).

115. Due to their anti-fungal activity, plant defensins have been investigated *in vitro* for the treatment of a number of human fungal conditions, including defensin def1 from the plant *Picramnia pentandra* for the treatment of fungal nail infections (van der Weerden et al., 2023), and over 20 different plant defensins, including those from peas, rice, Indian mustard and corn, for the treatment of candidiasis (reviewed in Finkina et al., 2024). Two clinical trials have been conducted in Australia to test plant defensin HXP124 in fungal nail infections ([Australian New Zealand Clinical Trials Registry](#), accessed 8 August 2025).

4.5.6 Compositional analysis of the GM Purple Tomato fruit

116. Compositional analysis of tomatoes from the Del/Ros1-N variety in MoneyMaker was conducted and compared to that of non-GM MoneyMaker tomatoes (Table 4). Approximately 1 kg of ripe fruit (10 fruits) was harvested from each of 5 Del/Ros1-N in MoneyMaker plants and 5 non-GM control MoneyMaker plants at the same time and the same stage or ripening, then combined into 5 independent samples for each of the 2 varieties. Following the guidelines outlined in the *OECD Consensus Document on Compositional Considerations for New Varieties of Tomato* (OECD, 2008), the tomatoes were analysed for a number of nutrients and non-nutrients, including:

- proximates – protein, fat, total carbohydrates, fibre, ash
- minerals – magnesium and potassium
- carotenoids – β-carotene and lycopene
- vitamins – C, K and folate (B9).

Table 4. Nutrient composition of various tomato varieties

Analyte	unit	Non-GM red tomato fruit	GM Purple Tomato fruit	USDA (avg)	USDA (min) ^a	USDA (max)	McCance and Widdowson ^b
Moisture	g/100 g	94.72 ± 0.12	95.1 ± 0.12	94.52	92.7	95.73	94.6
Crude protein	g/100 g	0.64 ± 0.05	0.70 ± 0.09	0.88	0.59	1.06	0.5
Ash	g/100 g	0.32 ± 0.02	0.48 ± 0.02	0.50	0.37	0.60	n/a
Carbohydrates	g/100 g	3.06 ± 0.29	3.26 ± 0.27	3.89	n/a	n/a	3
Fructose	g/100 g	1.46 ± 0.05	1.22 ± 0.09	1.37	1.1	2.32	1.6
Galactose	g/100 g	<0.1 ± 0	0.1 ± 0	0.00	0.00	0.00	0.00
Glucose	g/100 g	1.26 ± 0.02	1.04 ± 0.08	1.25	0.49	2.67	1.4
Lactose	g/100 g	<0.1 ± 0	0.1 ± 0	0.00	0.00	0.00	0.00
Maltose	g/100 g	<0.1 ± 0	0.1 ± 0	0.00	0.00	0.00	0.00
Sucrose	g/100 g	<0.1 ± 0	0.1 ± 0	0.00	0.00	0.02	0.00
Total sugar	g/100 g	2.72 ± 0.06	2.24 ± 0.17	2.63	1.59	5.01	3.00
Total fibre ^c	g/100 g	1.1 ± 0.2	0.7 ± 0.1	1.2	0.7	2	1
Energy in kilocalories	kcal/100 g	18.4 ± 0.83	16.8 ± 0.77	18	n/a	n/a	4
Energy in kilojoules	kJ/100 g	81.8 ± 1.78	71 ± 2.95	74	n/a	n/a	61
Total fat	g/100 g	<0.3 ± 0.04	<0.3 ± 0	0.2	0.07	0.80	0.10
Salt	g/100 g	<0.025 ± 0	<0.025 ± 0	n/a	n/a	n/a	n/a

Analyte	unit	Non-GM red tomato fruit	GM Purple Tomato fruit	USDA (avg)	USDA (min) ^a	USDA (max)	McCance and Widdowson ^b
Monounsaturated FAs	g/100 g	<0.1 ± 0	<0.1 ± 0	0.031	n/a	n/a	0.03
Polyunsaturated FAs	g/100 g	<0.1 ± 0	<0.1 ± 0	0.083	n/a	n/a	0.05
Saturated FAs	g/100 g	<0.1 ± 0	<0.1 ± 0	0.028	n/a	n/a	0.03
Trans FAs	g/100 g	<0.1 ± 0	<0.1 ± 0	n/a	n/a	n/a	0
<hr/>							
Magnesium	g/100 g	0.01 ± 0.00	0.01 ± 0.00	0.011	0.007	0.015	0.008
Potassium	g/100 g	0.16 ± 0.00	0.23 ± 0.01	0.237	0.144	0.385	0.0223
Sodium	g/100 g	<0.01 ± 0	0.01 ± 0.00	0.005	0.001	0.024	0.002
<hr/>							
beta carotene	µg/100 g	451.6 ± 42.4	661.8 ± 64.8	449	184	572	349
Folate (vitamin B9)	µg/100 g	8.92 ± 0.28	14.22 ± 0.31	13.7	7.8	19.8	23
Ascorbate (vitamin C)	mg/100 g	6.86 ± 0.18	8.1 ± 0.86	15	1	36	22
Phylloquinone (vitamin K1)	µg/100 g	2.69 ± 0.14	1.99 ± 0.1	7.9	2.2	60	6
Lycopene	mg/kg	73.8*	59.9*	25.73	11.36	34.19	n/a

Source: * lycopene concentrations are unpublished information supplied by applicant, remaining data is from Martin and Butelli (2025).^a Average and min/max values from USDA Food Composition Databases Show Foods - Tomatoes, Red, Ripe, Raw, Year-round; ^b McCance and Widdowson: The Composition of Foods Integrated Dataset 2019; ^c as determined using methods approved by the Association of Official Analytical Chemists. FAs = fatty acids.

117. The composition of the GM Purple Tomatoes is similar to the non-GM MoneyMaker control. Martin and Butelli (2025) noted that there was <25% difference compared to the non-GM control in most components measured, with folate (see table) and α -tomatine (see below) showing >25% difference to the non-GM control. The lycopene values for both the GM Purple Tomato and the non-GM MoneyMaker control are much higher than the USDA ranges shown in Table 4, but it appears this range is relatively low and narrow compared to the literature which includes ranges such as 8.8–77.4 mg lycopene/kg fresh weight (reviewed in Story et al., 2010).

118. As discussed in Section 3.4.1, plants in the Solanaceous family produce several alkaloids, with tomatine being the main alkaloid found in tomatoes. α -tomatine levels were measured in freeze-dried Del/Ros1-N in MoneyMaker tomatoes and MoneyMaker non-GM control. Del/Ros1-N in MoneyMaker tomatoes had more than double the levels of α -tomatine compared to the control (measured at 88 mg/kg vs 36.8 mg/kg dry sample, converted to 5.17 mg/kg vs 2.18 mg/kg fresh weight) but were well within the typical reported range for non-GM tomato varieties of negligible to 23 mg/kg fresh weight (OECD, 2008). The applicant has stated that increased tomatine levels may be a result of the slower ripening of the GMO (discussed further in Section 4.5.7), as tomatine levels decrease during ripening.

119. Compositional analysis was not conducted on the GMO in the MoneyMaker x Goldkrone background.

120. FSANZ has assessed the safety of the GM Purple Tomato and its products as food for human consumption under application [A1333](#). As part of the assessment, FSANZ examined the nutritional composition of the GM Purple Tomato and concluded that, other than the intended increase in anthocyanins and associated metabolites, there were no biologically meaningful differences in the levels of key constituents in the GM Purple Tomato fruit compared to non-GM tomato varieties available on the market.

4.5.7 Phenotypic characterisation

121. Phenotypic characteristics of the GMO from a greenhouse trial are shown in Table 5. This phenotypic characterisation was performed using the GMO crossed into a cherry tomato background

(Goldkrone), so the fruit are much smaller than the GMO in the MoneyMaker background that was used for the compositional analysis (Section 4.5.6).

Table 5. Phenotypic characteristics of the GM MoneyMaker x Goldkrone variety

Seedling Characteristics	Seedlings (2-15 cm) have anthocyanin pigmentation on the hypocotyl at 3-5 weeks post sowing.
Plant Habit & Growth	Plants have an indeterminate, moderately sprawling growth habit with intermediate branching with 2-3 nodes between inflorescences along the length of the main stem. Mature plants can reach 300 cm or taller depending on pruning and season length.
Leaf & Flower Morphology	Mature plants have 'potato-type,' smooth (non-rugose) and bipinnate leaves. Flowers are yellow, non-fasciated, and remain fused in anther cone at anthesis.
Fruit & truss characteristics	Fruit is a round, 'Cherry' type tomato; individual fruit weight ranges from 10-18g (average 14.4 +/- 4.2g) and average fruit size approximately 33 mm at its widest point. As the fruit matures, fruit colour transitions from green to chocolate brown (late breaker stage) to a dark purple or 'black' when ripe. Ripe fruit have a dark purple skin and a purple/violet flesh and gel. Fruit can be harvested on the vine or loose as fruit readily detaches from the calyx without splitting or cracking at the fruit abscission zone. Truss architecture tends to be moderately branched with one or more forks per truss.

122. The GM Purple Tomato seedlings display anthocyanin pigmentation on the hypocotyl at 4-5 weeks post sowing (Table 5), indicating anthocyanin production in the vegetative tissues is functioning similar to non-GM tomatoes which also produce anthocyanins in the hypocotyl (as discussed in Section 4.1.1.2). The applicant has stated that the purple phenotype has not been observed in the mature plants. Flowers are a normal yellow colour, and the colour of the developing fruit is green before changing during ripening to a brown then dark purple colour. Together, these observations indicate that the E8 promoter is driving expression of the *Rosea1* and *Delila* genes, and therefore increasing anthocyanins, only in the fruit during ripening and not in other tissues or at other times. As discussed in Section 4.1.3, the E8 promoter responds to the presence of ethylene, which is produced during fruit ripening.

123. Purple fruit from the GMO in the MicroTom background have a similar size, shape, and number of seeds compared to non-GM MicroTom (Zhang et al., 2013).

124. The GM Purple Tomato fruit in the MicroTom background displayed delayed ripening after breaker stage compared to red fruit (Zhang et al., 2013). A statement on the [Norfolk Health Produce website – Tips for Growing Purple Tomatoes](#) (accessed 16 July 2025) says “Ready for harvest when fruit begins to feel soft and readily releases from the stem. Be patient - purple color develops before fruit is fully ripe.” It is well established that levels of ethylene increase rapidly in tomato fruit during the breaker stage, which is an early stage of fruit ripening (Huang et al., 2022). In the GMO, expression of *Delila* and *Rosea1* is controlled by the E8 promoter which responds to the presence of ethylene (Section 4.1.3). This may explain why anthocyanins, and therefore purple colouring, accumulate before fruit is fully ripe. In contrast,

accumulation of anthocyanins in the non-GM Indigo Rose tomato is induced by light (Sun et al., 2020) and inhibited by ethylene (Xu et al., 2022).

125. The shelf life of the GMO in the MicroTom background was compared to the MicroTom control after harvesting at 14 days post breaker stage, with fruit softening during late stage ripening and pathogen susceptibility being important factors for shelf life (Zhang et al., 2013). The GM Purple Tomatoes displayed reduced softening during late-stage ripening and decreased susceptibility to the fungus *Botrytis cinerea*, resulting in double the shelf life compared to non-GM MicroTom tomatoes. The delay in late-stage fruit softening is thought to be due to the antioxidant effects of the anthocyanins reducing oxidative stress and tissue damage in the GM fruit. Susceptibility to the fungus *B. cinerea* is inversely related to the anthocyanin concentration and thought to be due to the antioxidant activity of the anthocyanins on reactive oxygen species (ROS), therefore reducing the spread of the ROS burst that is important for fungal infection by necrotrophic pathogens like *B. cinerea*. It is noted that the increased expression of a plant defensin (Section 4.5.5) could play a role in the reduced susceptibility of the GM fruit to fungal infection, as plant defensins commonly have activity against fungi including *B. cinerea*, however when agar plates were supplemented with fruit juice from the GM Purple Tomato or non-GM red tomato neither inhibited fungal growth. This indicates that the reduced susceptibility of the GM Purple Tomato fruit to fungal infection is likely the result of other components of the GM fruit such as anthocyanins modulating living cell stress responses rather than defensins directly killing the fungus.

4.5.8 Mouse feeding study

126. In order to assess any benefits of the increased anthocyanin production in the GM Purple Tomato, a survival study was conducted in cancer-prone p53 knockout mice, which have an average life expectancy of approximately 140 days (Butelli et al., 2008). From weaning (approximately 14 days old), mice were fed either standard diet mouse pellets, pellets supplemented with 10% red tomato powder or pellets supplemented with 10% Purple Tomato powder. Mice fed pellets supplemented with GM Purple Tomato powder had an increased average lifespan (average of 182.2 days survival and maximum of 260 days, n=20), compared to those fed pellets supplemented with non-GM red tomato powder (average 145.9 days, maximum 213 days, n=15) and standard pellets (average 142 days, maximum 211 days, n=24). Benefits are not in the scope of the Gene Technology legislation and will not be discussed further. Although not a toxicological evaluation, considering the increase in survival of the GM Purple Tomato-supplemented mice, this study provides some indication that mice fed a diet supplemented with GM Purple Tomato powder did not experience any observed toxicity or increased mortality following chronic exposure.

Section 5 The receiving environment

127. The receiving environment forms part of the context in which the risks associated with dealings involving the GMOs are assessed. Relevant information about the receiving environment includes abiotic and biotic interactions of the crop with the environment where the release would occur; agronomic practices for the crop; presence of plants that are sexually compatible with the GMOs; and background presence of the gene(s) used in the genetic modification (OGTR, 2013).

128. The applicant has proposed to commercially grow the GM Purple Tomato. As discussed further in Section 5.3.2, individuals may also grow the tomatoes. Therefore, for this licence application, it is considered that the receiving environment is all of Australia. Relevant information about the receiving environment in Australia is presented below.

5.1 Relevant abiotic factors

129. In line with the warm climates from which tomatoes originated, tomato plants have an optimal growth temperature of approximately 24 to 26°C during the day and 15 to 17°C at night (Li et al., 2023). Tomato plants are frost sensitive and can become stressed at temperatures between 0 to 12°C (Liu et al., 2012), although gradual acclimation to lower temperatures can reduce cold stress (Barrero-Gil et al., 2016; Mesa et al., 2022). Higher temperatures (above 30°C) also negatively impact tomato plants, inducing heat stress and reducing pollination and fruit set (Pressman et al., 2002; Sato et al., 2001). Tomato fruit are also

sensitive to temperature, with temperature extremes affecting fruit ripening (Adams, 2001). A temperature range of 15 to 35°C is required for seed germination with temperatures between 20 to 30°C optimal (Fullelove et al., 1998).

130. Tomato plants are prone to waterlogging (Umicevic et al., 2024). Excess moisture also makes tomatoes susceptible to disease, particularly through contact with wet soil and soil-borne pathogens. In climates with high rainfall it is recommended to trellis tomatoes to reduce contact of the plant with wet soil and/or avoid growing during the rainy season (Fullelove et al., 1998).

131. Considering these abiotic factors, in Australia tomatoes are usually grown throughout the cooler, drier conditions in autumn, winter and spring in warm climates to avoid excessive heat and moisture, and during spring and summer in colder climates to avoid frost (Fullelove et al., 1998).

5.2 Relevant biotic factors

132. Tomatoes are susceptible to various pests and diseases.

133. Common types of diseases include (McDougall et al., 2013):

- **fungal and fungal-like:** late blight (*Phytophthora infestans*), powdery mildew (*Leveillula taurica*, *Oidium lycopersici*, *O. neolyopersici*), grey mold (*Botrytis cinerea*), Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*), *Verticillium* wilt (*Verticillium dahliae*)
- **bacterial:** bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*), bacterial spot (*Xanthomonas euvesicatoria*, *X. vesicatoria*, *X. perforans*, *X. gardneri*), bacterial wilt (*Ralstonia solanacearum*)
- **viral:** tomato leaf curl (Begomoviruses, including tomato leaf curl virus), alfalfa mosaic (alfalfa mosaic virus), fern leaf (cucumber mosaic virus), tobacco mosaic (tobacco mosaic virus), tomato brown rugose fruit virus (ToBRFV)
- **other:** root knot nematode (*Meloidogyne* spp).

134. Soil-borne diseases like *Fusarium* have been shown to have significant impacts on the Australian tomato industry, with crop rotation, soil sterilisation and soil fumigation being some of the control measures (Ma et al., 2023). Imported tomato seeds also present a disease risk to the Australian tomato industry (Constable et al., 2019). ToBRFV is a highly contagious virus of tomatoes, chillies and capsicums that was detected in Australia in 2024 and has been recently declared not feasible to eradicate ([Australian Government Outbreak website](#), accessed 4 August 2025). ToBRFV can reduce the commercial yield of tomatoes by 75% ([PIRSA website](#), accessed 4 August 2025).

135. Common insect and mite pests include mites (e.g. Tomato russet mite *Aculops lycopersici*), thrips (e.g. tomato thrips *Frankliniella schultzei*), aphids (e.g. *Macrosiphum euphorbiae*), and potato moth (*Phthorimaea operculella*) (McDougall et al., 2013).

5.3 Relevant cultivation practices in Australia

136. It is anticipated that the cultivation practices for the proposed release will not differ from the standard practices used for current commercial non-GM tomatoes or for growing by home gardeners.

5.3.1 Commercial tomato production in Australia

137. The applicant has stated that the aim of this commercial release is to enable commercial greenhouse production of the GM Purple Tomato for the fresh market. The applicant has also stated that the GM Purple Tomatoes may be used to make processed products such as tomato paste, sauce, and soups.

138. According to the Australian Horticulture Statistics Handbook (Hort Innovation, 2024), 437,596 tonnes (t) of tomatoes were produced in Australia in the year ending June 2024. Only approximately 1000 t (<1%) was exported, with 51% going to the fresh supply market and 49% going to processing. No fresh tomatoes were imported.

139. Tomatoes are grown commercially in most States and Territories in Australia, with the biggest producers being Victoria (59.2%), then South Australia (14.0%), Queensland (11.4%), New South Wales

(10.4%), Western Australia (4.4%) and Tasmania (0.5%). With the wide range of climates across Australia, production occurs year-round.

140. The handbook notes that conventional growing in fields is still the predominant production system (71.8% production), however technological improvements have seen an increase in glasshouse production (24.1%), followed by polyhouse and tunnel production (4.1%). Glasshouse production is highest in South Australia (94 hectares (ha)), Victoria (81 ha) and New South Wales (44 ha). Although the applicant has stated that the GM Purple Tomatoes are proposed to be grown in greenhouses, commercial production of the GM Purple Tomatoes in greenhouses as well as in the field will be considered.

141. An industry report by the Australian Processing Tomato Research Council Inc., the Annual Industry Survey 2024, indicates that a small number of specialist growers produce most of the tomatoes for processing across northern Victoria (70% of the entire crop for processing) and southern New South Wales (remaining 30%) (Australian Processing Tomato Research Council, 2024). This report indicated that 3 organisations processed the entire crop grown on 2,741 ha of the 2023/24 season. Yields were at approximately 80.7 t/ha which is higher than the previous season but below the industry standard of approximately 100 t/ha. Adverse weather conditions have directly caused yield losses as has been observed previously. Two cultivars, H3402 and H1015 constituted 61% of the total area grown for processing tomatoes in 2023/24. Most plants were grown to seedling stage and then transplanted (85%) with the remaining 15% being direct sown.

142. In the year ending 2024, Australia imported 155,503 t of preserved tomatoes and 32,208 kilolitres of tomato juice (Hort Innovation, 2024).

143. Tomato pomace, the waste residue from the manufacture of tomato juice, sauce, puree, and paste, may be incorporated into animal feed in small quantities (<30%) as a byproduct energy concentrate ([Agriculture Victoria -Unusual Feedstuffs](#), accessed 9 July 2025). Tomato pomace is approximately 60% seed and 40% peel (Kumar et al., 2022).

5.3.2 *Cultivation by home gardeners*

144. Although the applicant has not specifically indicated their intention to sell seed packets of the GM Purple Tomato to home gardeners in Australia, a commercial release may involve such sale in the future and seeds are being sold to home gardeners in the US. Tomatoes may also be cultivated from the seeds of fruit purchased commercially. Therefore, cultivation by home gardeners forms part of the risk context for this proposed release.

145. Growing edible produce at home is a common practice in Australian households, with an estimated 45% growing some of their own food (The Australia Institute, 2024). Seed packets and seedlings can be purchased from various sources, including plant nurseries and online stores. Tomatoes are one of the most popular choices, with well over 100 varieties available to Australian gardeners (e.g. [Seeds of Plenty, Yates, The Seed Collection](#)). Tomatoes can be grown in all climates across Australia. In tropical and subtropical climates, they are best grown in autumn and winter when the weather is drier, in cool or cold climates they are best planted in spring after last frosts to grow over summer (e.g. [Yates – How to Grow Tomatoes](#), accessed 8 July 2025). Home gardeners are encouraged to hand pollinate tomato flowers using an electric toothbrush or paintbrush to boost pollination rates, particularly if growing in a home greenhouse (e.g. [The Seed Collection - How to Hand Pollinate Tomatoes: Two Methods to Boost Your Harvest](#), accessed 1 August 2025).

146. Tomatoes are well known to grow as volunteer plants (self-seeded plants that have not been intentionally planted), either from kitchen waste being used for home compost or from dropped fruit from plants grown in the home garden. Gardeners may keep these volunteer plants as a source of new tomato seedlings (e.g. [ABC Gardening](#), accessed 9 July 2025).

5.4 Presence of related species in the receiving environment

147. As discussed in Sections 5.3.1 – 5.3.2, tomatoes for commercial production are grown in most Australian States and Territories and home gardeners may grow tomatoes across Australia.

148. Tomatoes can hybridise with several wild relatives, including *S. pimpinellifolium*, *S. chilense*, *S. lycopersicoides*, *S. pennellii*, and *S. neorickii* (Brog et al., 2019; Mes et al., 2008; Sharma et al., 2008). Seeds of *S. pimpinellifolium*, also known as the currant tomato, can be purchased by home gardeners in Australia (e.g. [Boondie Seeds, Seeds Station](#), accessed 9 July 2025) but are not grown commercially. Like domesticated tomato, *S. pimpinellifolium* primarily self-pollinates, but it also displays variation in floral structures which can either promote or reduce outcrossing (Georgiady et al., 2002). In a laboratory setting, *S. pimpinellifolium* has been successfully crossed bidirectionally (both as the female and male in the cross) with *S. lycopersicum* (Sharma et al., 2008). Natural hybrids between *S. lycopersicum* and *S. pimpinellifolium* are probably rare but possible. It is thought that the weedy *S. lycopersicum* var *cerasiforme* found in Peru and Ecuador may be a hybrid of *S. lycopersicum* with *S. pimpinellifolium* (Blanca et al., 2012; Nesbitt and Tanksley, 2002; Ranc et al., 2008). None of the other wild relatives of tomatoes are present in Australia ([Altas of Living Australia](#), accessed 9 July 2025).

149. Several native *Solanum* species are present in Australia, including bush tomato. In a laboratory setting, *S. orbiculatum*, a species of bush tomato found in the arid areas of Western Australia, South Australia, and the Northern Territory, was able to pollinate *S. lycopersicum* only if *S. orbiculatum* was the male parent, however there was no fruit or seed set due to post-zygotic barriers (Ahmad et al., 2023).

5.5 Presence of the introduced genes and their encoded proteins in the environment

150. All the introduced genes are isolated from naturally occurring organisms that are already widespread and prevalent in the environment.

151. The *Delila* and *Rosea1* genes are derived from garden snapdragon (*A. majus*). *A. majus* is a flowering plant that is native to the Mediterranean and has been bred to have flowers in a variety of colours and double flowered forms with increased petals (reviewed in Schwarz-Sommer et al., 2003). *A. majus* is grown throughout Australia for its ornamental qualities, with seeds or plants available from retailers (e.g. [Bunnings](#), accessed 9 July 2025). Snapdragon flowers can also be purchased as part of edible mixes (e.g. [Edible Flowers Melbourne](#), accessed 10 July 2025).

152. The *nptII* gene was isolated from *E. coli*, a common bacterium that is widespread in human and animal digestive systems and in the environment in Australia (reviewed in Jang et al., 2017). As such, it is expected that humans, animals and microorganisms routinely encounter the encoded protein.

5.6 Use of kanamycin, neomycin and related antibiotics in veterinary and human medicine

153. The *nptII* gene in the GM Purple Tomato encodes an enzyme that inactivates certain aminoglycoside antibiotics, including kanamycin, neomycin, paromomycin, ribostamycin, lividomycin, butirosin, gentamicin and isepamicin (Shaw et al., 1993). Of these antibiotics, only neomycin and gentamicin are approved for use in veterinary and human medicine in Australia (Table 6) so will be discussed further.

Table 6. Registration of veterinary and human medicines containing kanamycin and related antibiotics in Australia

Antibiotic	Registered as a veterinary medicine in Australia? ^a	Registered as a human therapeutic in Australia? ^b
Kanamycin	No	No
Neomycin	Yes	Yes
Paromomycin	No	No
Ribostamycin	No	No
Lividomycin	No	No

Antibiotic	Registered as a veterinary medicine in Australia? ^a	Registered as a human therapeutic in Australia? ^b
Butirosin	No	No
Gentamicin	Yes	Yes
Isepamicin	No	No
Geneticin	No	No

a. APVMA PubCRIS database, accessed 7 August 2025, b. Australian Register of Therapeutic Goods (ARTG), accessed 7 August 2025.

154. Aminoglycoside antibiotics like gentamicin and neomycin are mainly used to treat infections with aerobic gram-negative bacteria in both humans and animals. The World Organisation for Animal Health (OIE) lists aminoglycoside antibiotics, including gentamicin and neomycin, as Veterinary Critically Important Antimicrobial Agents, as they are effective in a wide range of applications and noted that gentamicin is used in *Pseudomonas aeruginosa* infections with few available alternatives (OIE, 2021). The World Health Organization List of Medically Important Antimicrobials lists aminoglycosides, including neomycin and gentamicin, as Critically Important Antimicrobials (CIA), the second highest category (WHO, 2024). In the Australian context, the Australian Strategic and Technical Advisory Group on Antimicrobial Resistance (ASTAG) has listed neomycin individually as Low Importance in Australia (i.e. there are a reasonable number of alternative antibacterials in different classes available to treat or prevent most human infections even if antibacterial resistance develops) and gentamicin as Medium Importance (i.e. there are some alternative antibacterials in different classes available to treat or prevent human infections, but less than for those rated as Low Importance) (ASTAG, 2018).

Section 6 Relevant Australian and international approvals

6.1 Australian approvals

6.1.1 Approvals by the Regulator

155. The GM Purple Tomato has not previously been approved for release in Australia.

156. There have been several previous approvals for commercial release of flowers with altered pigmentation via increased anthocyanin production (Table 7).

Table 7. Previous licences issued by the Regulator for the commercial release of GM flowers with altered flower colour and increased anthocyanins

Licence number	Project title	Licence holder	Licence status
DIR 030	Ongoing commercial release of colour modified carnations	Florigene Pty Ltd	Licence subsequently ceased and a determination issued by the Regulator as GMO Register Reg-001.
DIR 090	Commercial release of rose genetically modified for altered flower colour	Florigene Pty Ltd	Surrendered
DIR 134	Commercial import and distribution of genetically modified carnation cut-flowers with altered flower colour	International Flower Developments Pty Ltd	Licence subsequently ceased and a determination issued by the Regulator as GMO Register Reg-002.
DIR 191	Commercial import and distribution of chrysanthemum genetically modified for altered flower colour	International Flower Developments Pty Ltd	Current

157. Details of all GMOs approved by the Regulator for commercial release in Australia under a licence are available from the [OGTR website](#). Dealings with GMOs authorised by the Regulator as safe for anyone to grow in Australia without a licence are listed on the [GMO Register](#).

6.1.2 Approvals by other government agencies

158. The GM Purple Tomato has not previously been approved by any other government agencies in Australia.

159. FSANZ assessed the food safety of the GM Purple Tomato and its products as food for human consumption as application A1333. Their assessment found that food derived from the GM Purple Tomato is as safe as food from conventional tomatoes already in the Australian and New Zealand food supply. In October 2025, FSANZ approved this GM Purple Tomato for sale as a food in Australia and New Zealand. The GM tomatoes and any derived food products are subject to mandatory GM labelling.. More information is available on the [FSANZ website](#). The application was assessed under the Health Canada-FSANZ Shared Assessment Process.

6.2 International approvals

160. In 2022, the US Department of Agriculture Animal and Plant Health Inspection Service (APHIS) deemed the GM Purple Tomato to not be a regulated article as there was no plausible pathway identified by which the GMO would pose an increased plant pest risk compared to non-GM tomato (Martin and Butelli, 2025; USDA, 2022). Seed has been sold to home gardeners since 2024. The applicant has stated that over 13,000 seed packets were sold to home gardeners in 2024.

161. The US Food and Drug Administration authorised the GM Purple Tomato as food in 2023. In 2024, commercially produced fruit began to be sold in US grocery stores. The applicant has stated that commercial cultivation of over 8000 GM Purple Tomato plants occurred at a single facility in Virginia and approximately 29 tonnes of fruit has been sold in hundreds of retail grocery stores. Some cultivation also occurred by regional growers to supply local farmers markets.

162. The 2025 release in the US is still ongoing. Seeds and seedlings were available to home gardeners in 2025. It is estimated that approximately 60 tonnes of fruit will be sold in retail by the end of the year. As of August 2025, the applicant has stated that no adverse effects or unintended consequences of any kind have been reported from the US commercial release.

163. In August 2025, approvals were granted for both food safety and unconfined release of the GM Purple Tomato in Canada.

Chapter 2 Risk assessment

Section 1 Introduction

164. The risk assessment identifies and characterises risks to the health and safety of people or to the environment from dealings with GMOs, posed by or as the result of gene technology (Figure 11). Risks are identified within the established risk assessment context (Chapter 1), taking into account current scientific and technical knowledge. A consideration of uncertainty, in particular knowledge gaps, occurs throughout the risk assessment process.

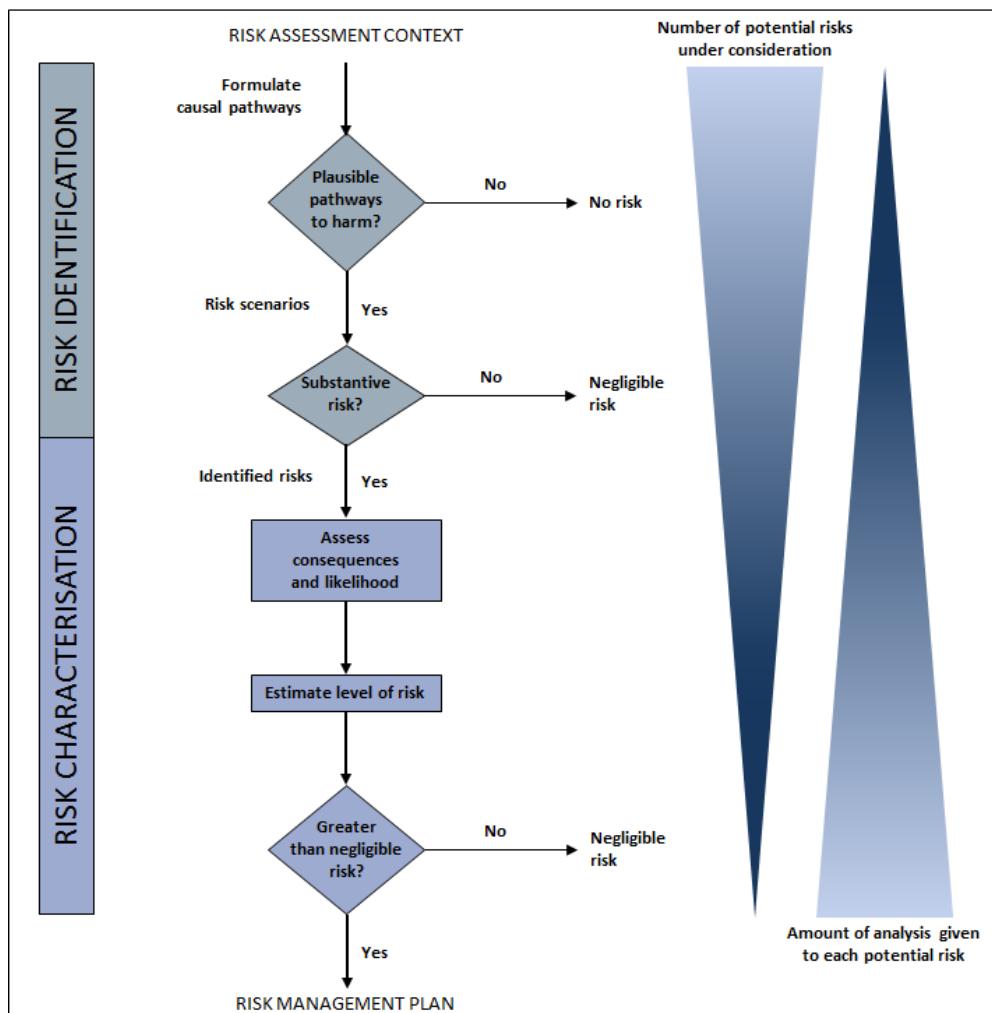


Figure 11. The risk assessment process

165. The Regulator uses a number of techniques to identify risks, including checklists, brainstorming, reported international experience and consultation (OGTR, 2013). Risk scenarios examined in RARMPs prepared for licence applications for the same or similar GMOs, are also considered.

166. Risk identification first considers a wide range of circumstances in which the GMO, or the introduced genetic material, could come into contact with people or the environment. This leads to postulating plausible causal pathways that may give rise to harm for people or the environment from dealings with a GMO. These are risk scenarios. These risk scenarios are screened to identify those that are considered to have a reasonable chance of causing harm in the short or long term. Pathways that do not lead to harm, or those that could not plausibly occur, do not advance in the risk assessment process (Figure 11), that is, the risk is considered to be no greater than negligible.

167. Risks identified as being potentially greater than negligible are characterised in terms of the potential seriousness of harm (Consequence assessment) and the likelihood of harm (Likelihood

assessment). Risk evaluation then combines the Consequence and Likelihood assessments to estimate the level of risk and determine whether risk treatment measures are required. The potential for interactions between risks is also considered.

168. A weed risk assessment approach is used to identify traits that may contribute to risks from GM plants, as this approach addresses the full range of potential adverse outcomes associated with plants. In particular, novel traits that may increase the potential of the GMO to spread and persist in the environment or increase the level of potential harm compared with the parental plant(s) are used to postulate risk scenarios (Keese et al., 2014). Risk scenarios postulated in previous RARMPs prepared for licence applications for the same or similar GMOs, are also considered.

Section 2 Risk identification

169. Postulated risk scenarios are comprised of three components (Figure 12):

- I. the source of potential harm (risk source)
- II. a plausible causal linkage to potential harm (causal pathway)
- III. potential harm to people or the environment.

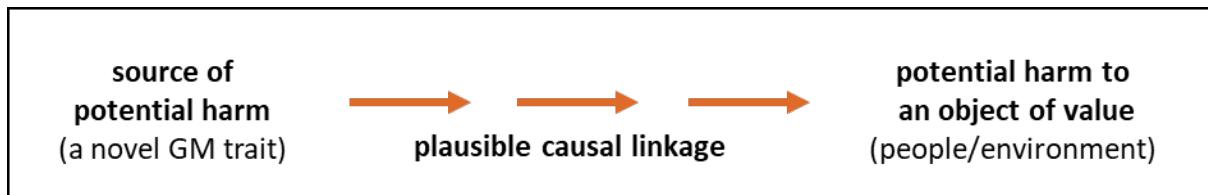


Figure 12. Risk scenario

170. When postulating relevant risk scenarios, the risk context is taken into account, including the following factors detailed in Chapter 1:

- the proposed dealings
- the proposed limits including the extent and scale of the proposed dealings
- the proposed controls to limit the spread and persistence of the GMOs
- the characteristics of the parent organism(s).

2.1 Risk source

171. The sources of potential harms can be intended novel GM traits associated with one or more introduced genetic elements, or unintended effects/traits arising from the use of gene technology.

172. As discussed in Chapter 1, the GM Purple Tomato has been modified by the introduction of 2 genes from *Antirrhinum majus* intended to activate anthocyanin production during tomato fruit ripening and the *nptII* gene from *E. coli* which was used as a selectable marker during development of the GMO. These introduced genes will be considered further as a source of potential harm.

173. The introduced genes are controlled by regulatory sequences. These were originally derived from a plant, a plant virus and a bacterium (Table 2). Regulatory sequences are naturally present in all plants, and the introduced elements are expected to operate in similar ways to endogenous elements. The regulatory sequences are DNA that is not expressed as a protein, so exposure is to the DNA only and dietary DNA has no toxicity (Delaney et al., 2018). Hence, potential harms from the regulatory sequences will not be considered further.

174. The genetic modifications involving introduction of genes have the potential to cause unintended effects in several ways. These include insertional effects such as interruptions, deletions, duplications or rearrangements of the genome, which can lead to altered expression of endogenous genes. There could also be increased metabolic burden due to expression of the introduced proteins, novel traits arising out of interactions with non-target proteins and secondary effects arising from altered substrate or product levels

in biochemical pathways. However, these types of effects also occur spontaneously and in plants generated by conventional breeding. Accepted conventional breeding techniques such as hybridisation, mutagenesis and somaclonal variation can have a much larger impact on the plant genome than genetic engineering (Schnell et al., 2015). While plants generated by conventional breeding have a long history of safe use, and there are no documented cases where conventional breeding has resulted in the production of a novel toxin or allergen in a crop (Steiner et al., 2013), the upregulation of a defensin in the GM Purple Tomato was observed and so this is considered further below.

2.2 Causal pathway

175. The following factors are taken into account when postulating plausible causal pathways to potential harm:

- routes of exposure to the GMOs, the introduced gene(s) and gene product(s)
- potential exposure to the introduced gene(s) and gene product(s) from other sources in the environment
- the environment at the site(s) of release
- agronomic management practices for the GMOs
- spread and persistence of the GMOs (e.g. reproductive characteristics, dispersal pathways and establishment potential)
- tolerance to abiotic conditions (e.g. climate, soil and rainfall patterns)
- tolerance to biotic stressors (e.g. pest, pathogens and weeds)
- tolerance to cultivation management practices
- gene transfer to sexually compatible organisms
- gene transfer by horizontal gene transfer (HGT)
- unauthorised activities.

176. Although all of these factors are taken into account, some are not included in risk scenarios because they have been considered in previous RARMPs and are not expected to give rise to substantive risks.

177. The potential for horizontal gene transfer (HGT) from GMOs to species that are not sexually compatible, and any possible adverse outcomes, have been reviewed in the literature (Keese, 2008; Philips et al., 2022) and assessed in previous RARMPs. No risk greater than negligible was identified, due to the rarity of HGT events and because the gene sequences are already present in the environment and available for transfer via demonstrated natural mechanisms. Therefore, HGT of *Delila* and *Rosea1* will not be assessed further. As antibiotic selectable markers are of public interest, HGT of the *nptII* gene will be considered further.

178. Previous RARMPs have considered the potential for unauthorised activities to lead to an adverse outcome. The Act provides for substantial penalties for non-compliance and unauthorised dealings with GMOs. The Act also requires the Regulator to have regard to the suitability of the applicant to hold a licence prior to the issuing of the licence. These legislative provisions are considered sufficient to minimise risks from unauthorised activities, and no risk greater than negligible was identified in previous RARMPs. Therefore, unauthorised activities will not be considered further.

2.3 Potential harm

179. Potential harms from GM plants are based on those used to assess risk from weeds (Keese et al., 2014; Virtue, 2004) including:

- harm to the health of people or desirable organisms³, including toxicity/allergenicity
- reduced biodiversity through harm to other organisms or ecosystems
- reduced establishment or yield of desirable plants
- reduced products or services from the land use
- restricted movement of people, animals, vehicles, machinery and/or water
- reduced quality of the biotic environment (e.g. providing food or shelter for pests or pathogens) or abiotic environment (e.g. negative effects on fire regimes, nutrient levels, soil salinity, soil stability or soil water table).

180. Judgements of what is considered harm depend on the management objectives of the land where the GM plant may be present. A plant species may have different weed risk potential in different land uses such as dryland cropping or nature conservation.

2.4 Postulated risk scenarios

181. Four risk scenarios were postulated and screened to identify any substantive risks. These scenarios are summarised in Table 8 and are examined in Sections 2.4.1 to 2.4.4.

182. In the context of the activities proposed by the applicant and considering both the short and long term, none of these risk scenarios gave rise to any substantive risks.

³ Desirable organisms are those that are valued and should be protected, while undesirable organisms cause harm and should be controlled (OGTR, 2013). This is determined by legislation, government policies, national and international guidance material, and widely accepted community norms. Undesirable plants that cause economic, social or environmental harm, or harm to human/animal health, are called weeds. Animals that cause harm are known as pests.

Table 8. Summary of risk scenarios from the proposed dealings with the GM Purple Tomato

Risk scenario	Risk source	Causal pathway	Potential harm	Substantive risk?	Reasons
1	The GM Purple Tomato	<p>Cultivation of the GM Purple Tomato</p> <p style="text-align: center;">↓</p> <p>Exposure of people and other desirable organisms to products of the introduced genes via ingestion, contact, or inhalation</p>	<p>Increased allergenicity or toxicity in people OR increased toxicity to other desirable organisms</p>	No	<ul style="list-style-type: none"> The introduced Ros1 and Del genes are from the edible snapdragon The introduced proteins and their pigment products are not expected to be toxic or allergenic The <i>nptII</i> gene and its product are present in other GM food and feed plants without causing adverse effects in people and other organisms Food safety assessment is conducted by FSANZ Tomato pollen is not wind borne Expression of Ros1/Del is limited to the ripening fruit.
2	<i>nptII</i> gene	<p>Cultivation of the GM Purple Tomato</p> <p style="text-align: center;">↓</p> <p>Consumption of GM Purple Tomato by humans or other desirable organisms AND Oral treatment with relevant antibiotics</p> <p style="text-align: center;">↓</p> <p>NPTII protein impacts effectiveness of antibiotic therapy</p> <p style="text-align: center;">↓</p> <p>Selection for antibiotic resistant bacteria in digestive tract</p>	<p>Exposure of bacteria to the <i>nptII</i> gene in the gut when GM fruit is consumed by people or animals OR in the soil or aquatic environments when plant or fruit material decomposes</p> <p style="text-align: center;">↓</p> <p>HGT of the <i>nptII</i> gene to gut, soil or aquatic bacteria</p>	Increased antimicrobial resistance	<ul style="list-style-type: none"> The NPTII protein is rapidly digested and therefore not expected to impact the effectiveness of relevant antibiotics taken orally HGT of the <i>nptII</i> gene from a GM plant to bacteria is considered to be highly unlikely. The <i>nptII</i> gene is already common in naturally occurring bacteria.

Risk scenario	Risk source	Causal pathway	Potential harm	Substantive risk?	Reasons
3	The GM Purple Tomato	<p>Cultivation of the GM Purple Tomato</p> <p style="text-align: center;">↓</p> <p>Persistence of the GM seeds in cultivated areas or dispersal of the GM Purple Tomato to nature reserves or intensive use areas</p> <p style="text-align: center;">↓</p> <p>Establishment of population of volunteer GM Purple Tomato in cultivated areas, nature reserves or intensive use areas</p>	<p>Increased allergenicity or toxicity in people or increased toxicity to other desirable organisms</p> <p>OR</p> <p>Reduced establishment or yield of desirable agricultural crops</p> <p>OR</p> <p>Reduced establishment or yield of desirable plants in the environment</p> <p>OR</p> <p>Reduced utility or quality of the environment</p> <p>OR</p> <p>Increased reservoir for pests or pathogens</p>	No	<ul style="list-style-type: none"> As discussed in Risk Scenario 1, no substantive risk was identified for increased toxicity or allergenicity. The spread and persistence of tomatoes is restricted by a range of biotic and abiotic factors, which are not expected to be altered by the introduced genes. GM volunteers can be controlled by standard weed management measures.
4	The GM Purple Tomato	<p>Cultivation of the GM Purple Tomato</p> <p style="text-align: center;">↓</p> <p>Outcrossing with sexually compatible plants</p> <p style="text-align: center;">↓</p> <p>Establishment of populations of hybrid GM plants expressing the introduced genes in the environment</p>	As per Risk Scenario 3	No	<ul style="list-style-type: none"> As discussed in Risk Scenario 1, no substantive risk was identified for increased toxicity or allergenicity. As discussed in Risk Scenario 3, the genetic modifications are not expected to alter the persistence or competitiveness of the GMO Purple Tomato.

Risk scenario	Risk source	Causal pathway	Potential harm	Substantive risk?	Reasons
					<ul style="list-style-type: none"> • Tomato is predominantly self-pollinating and has limited ability to outcross • If a GM hybrid emerged, the purple fruit trait is inherited in a dominant manner and is easily visually identified. • GM hybrids can be easily controlled.

2.4.1 Risk Scenario 1

<i>Risk source</i>	The GM Purple Tomato
<i>Causal pathway</i>	<p style="text-align: center;">↓</p> <p style="text-align: center;">Cultivation of the GM Purple Tomato</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Exposure of people and other desirable organisms to products of the introduced genes via ingestion, contact, or inhalation</p> <p style="text-align: center;">↓</p>
<i>Potential harm</i>	<p style="text-align: center;">Increased allergenicity or toxicity in people</p> <p style="text-align: center;">OR</p> <p style="text-align: center;">increased toxicity to other desirable organisms</p>

2.4.1.1 Risk source

183. The source of potential harm for this postulated risk scenario is the GM Purple Tomato.

2.4.1.2 Causal pathway

184. The applicant has stated that the GM Purple Tomato would be grown in commercial greenhouses in Australia. Although the applicant has not specifically indicated their intention to sell seed packets of the GM Purple Tomato to home gardeners in Australia, a commercial release may involve such sale in the future and GM tomatoes may also be cultivated by home gardeners from fruit purchased commercially.

185. The GM Purple Tomato fruit would enter general commerce and be used in the same way as non-GM tomato. The general public could be exposed to the fruit and other products derived from the fruit containing the introduced genetic changes and resulting proteins through contact and consumption. Workers in the greenhouse or home gardeners could be exposed to the GM Purple Tomato plants and pollen through inhalation or dermal contact. As tomato pollen is not wind borne, exposure to pollen is expected to be unlikely unless hand pollination is being conducted.

186. Desirable native and non-native organisms, such as birds, bats, possums, flying insects, and ground- or soil-dwelling species (e.g. earthworms, snakes or native rodents) could enter areas where the GM Purple tomato is being cultivated, whether commercially or in home gardens. These organisms could then feed on the fruit or other parts of the GM tomato plants or could come into contact with or consume GM plant material that falls to the ground or is left to decompose on the ground. Pollinators such as bees would be exposed to pollen from the GM Purple Tomato. Livestock may consume tomato pomace derived from processed GM Purple Tomato fruit. Pets, such as dogs, may consume the tomato fruit in the home or garden. Therefore, desirable organisms would be exposed to the GM tomato plants and fruit.

187. As fruit colour is important for attracting fruit eating animals, the purple colouration in the GM Purple Tomato may be more attractive to some animals than red, orange or yellow colouring in non-GM tomatoes. A study of fruit eating preferences in birds in Papua New Guinea found that red and purple artificial fruits were attacked at similar rates, and were strongly preferred over green fruit (Hazell et al., 2023). A different study in Sweden and Australia found that of the fruits commonly dispersed by birds, red fruit was the easiest for birds to detect compared to the background and black (dark purple or dark blue) was the least detectable (Todore et al., 2022). A study of fruit colour preferences in Madagascar and Uganda found that fruits dispersed by birds tend to be reflect more in the red spectrum and fruits dispersed by mammals tend to reflect more in the green spectrum, with no significant difference between birds and mammals in the blue spectrum (Valenta et al., 2018). A study of New Zealand brushtail possums found no colour preference in fruit eating (Cowan, 1992). Therefore, it is possible that some animal species may find the GM Purple Tomato more attractive, while others may not, and some may not be able to distinguish a difference in colouration.

188. Regarding exposure of desirable organisms to anthocyanins, there are non-GM tomatoes with purple skin (Chapter 1 Section 4.1.1.1) and there are many other anthocyanin-rich fruits and vegetables (Chapter 1 Section 4.4).

2.4.1.3 Potential harm

189. If humans and other desirable organisms were exposed to the GMO, the potential harms are increased toxicity or allergenicity to humans or increased toxicity to other desirable organisms. Allergic reactions are an adverse effect resulting from sensitisation to a chemical, followed by an allergic response upon subsequent exposure (Klaassen and Watkins, 2010). Allergenicity is the potential for a substance to be recognised by a person's body as a foreign and to elicit a (disproportionate) immunological reaction. Toxicity is an adverse effect of exposure to a substance (Klaassen and Watkins, 2010). The effect of a toxic agent depends on the dose, duration of exposure and exposure route, e.g. inhalation, ingestion or via the skin. Responses may be either immediate or delayed.

190. The expression of *Rosea1* and *Delila* is under the control of the fruit ripening specific E8 tomato promoter (Chapter 1, Section 4.1.3). This means that expression of these transcription factors, and increase in anthocyanins, is limited to the ripening fruit and not throughout the GM Purple Tomato plant. Exposure of organisms to the non-fruit parts of the GM Purple Tomato plant, including pollen, green tissues and roots, is expected to be equivalent to exposure to a non-GM tomato. Therefore, this section will focus on potential harms from expression of *Delila* and *Rosea1* only in the GM Purple Tomato fruit. The expression of *nptII* is under the control of a constitutive promoter, so is expected to be expressed throughout the plant.

191. As discussed in Chapter 1, Section 6.2, the GM Purple Tomato has been commercially released in the United States since 2024, both as fruit sold in grocery stores and seeds sold to home gardeners, with no adverse effects reported from this release.

Food safety assessment by FSANZ

192. FSANZ has assessed the safety of the GM Purple Tomato and its products as food for human consumption under application [A1333](#). As part of the assessment, FSANZ examined the following:

- molecular characteristics of the GMO
- nutritional composition of the GM Purple Tomato fruit, including protein and fat, ash and minerals, carbohydrates and fibre, vitamins and carotenoids, and glycoalkaloids (α -tomatine)
- scientific evidence on the safety of Rosea 1, Delia, NPTII, anthocyanins, and chlorogenic acid for human consumption.

193. As these aspects are the regulatory responsibility of FSANZ, they will not be considered in detail in this RARMP as relates to human consumption of the GM Purple Tomato fruit. FSANZ's approval version of the A1333 assessment notes that no public health and safety concerns were identified in the assessment of the GM Purple Tomato as food. Based on the data provided in the application and other available information, FSANZ have stated that food derived from GM Purple Tomato varieties is as safe for human consumption as food derived from conventional non-GM tomato varieties.

194. In coming to this conclusion FSANZ noted that:

- the *Rosea1* and *Delila* proteins are unlikely to be toxic or allergenic to humans as:
 - *Rosea1* and *Delila* are derived from edible snapdragon flowers, and their encoded proteins are homologous to proteins found in other plants, including commonly consumed foods
 - bioinformatic analysis showed that neither *Rosea1* or *Delila* has any amino acid similarity with known allergens or toxins of relevance to humans
 - both the *Rosea1* and *Delila* proteins are susceptible to digestion by pepsin and would be thoroughly degraded following ingestion.
- an extensive database demonstrating the safety of NPTII exists. Updated bioinformatic analyses provided for this application confirmed that the expressed protein is unlikely to be toxic or allergenic to humans
- regarding compositional analysis, there are no biologically meaningful differences in the levels of key constituents in fruit from the GM Purple Tomato compared to non-GM tomato varieties available on the market

- regarding nutritional impact, anthocyanins and associated metabolites are increased in the GM Purple Tomato fruit but within the natural range of variation for anthocyanins in commonly consumed foods.

195. These conclusions align with the information presented in Chapter 1, Section 4 of this RARMP.

196. In October 2025, FSANZ approved this GM Purple Tomato for sale as a food in Australia and New Zealand. The GM tomatoes and any derived food products are subject to mandatory GM labelling. More information is available on the [FSANZ website](#).

Potential for increased toxicity from exposure of other desirable organisms to the GM fruit

197. The *Delila* and *Rosea1* proteins are not expected to be toxic to desirable organisms for the same reasons they are not expected to be toxic to humans.

198. Anthocyanins are found in a wide variety of vegetative tissues, fruits, and flowers. The anthocyanin content of the GM Purple Tomato fruit is within the range of commonly grown and consumed foods (Chapter 1 Section 4.4). There are also non-GM tomatoes with purple skin from increased anthocyanins (Chapter 1 Section 4.1.1.1). Therefore, it is expected that desirable organisms would already be exposed to anthocyanins from other sources in the environment and exposure to the increased anthocyanins in the GM Purple Tomato fruit is not expected to lead to harm.

199. As discussed in Chapter 1 Section 4.5.6, GM Purple Tomatoes in the MoneyMaker background had more than double the levels of α -tomatine compared to the control. However, these levels were well within the typical reported range for other tomato varieties and so are not expected to pose an increased toxicity risk to desirable organisms compared to non-GM tomatoes. As *Delila* and *Rosea1* are under the control of a fruit specific promoter, it is not expected that α -tomatine levels would be significantly altered in the vegetative tissue of the GM Purple Tomato. Therefore, exposure to the vegetative tissue is not expected to pose an increased toxicity risk to desirable organisms, including for ground- or soil-dwelling organisms that would feed on decaying plant tissues.

200. There is no evidence that the *nptII* gene or the encoded protein is toxic ([OGTR Risk Assessment document](#) and references therein). GM foods containing the *nptII* gene have been assessed and approved for sale in Australia ([FSANZ website](#), accessed 30 June 2025). Therefore, it is expected that desirable organisms would already be exposed to NPTII from other sources in the environment and exposure to the NPTII protein in the GM Purple Tomato fruit is not expected to lead increased toxicity.

Potential harms from exposure to defensins in the GM fruit

201. Gene expression analysis of the GM Purple Tomato fruit has shown an almost 300-fold increase in expression of a tomato defensin gene *tgas118* compared to the non-GM control (Chapter 1 Section 4.5.4). The applicant has not quantified the amount of defensins in the GM Purple Tomato fruit, but given the increase in gene expression it is expected that levels of TGAS118 would be increased compared to levels in the non-GM control.

202. Plant defensins are peptides that are part of the innate immune system of plants, targeting mostly fungi.

203. *Tga118* is an endogenous tomato gene that is normally expressed in the roots, stems, leaves, flowerers and mature fruit of healthy tomato plants, predominately either in the stem and mature fruit, or in the flowers, depending on the study (Chapter 1 Section 4.5.5).

204. It is noted that extracts of the GM Purple Tomato fruit did not have activity against *B. cinerea* (Zhang et al., 2013), which may indicate that although there is a strong upregulation of the *tgas118* gene, the levels of TGAS118 in the GM Purple Tomato are not sufficient to have anti-fungal activity. Although it is unknown whether TGAS118 has activity against *B. cinerea*, it is noted that the closely related tomato defensin DEF2 has been shown to have activity against that particular fungus (Stotz et al., 2009a).

205. As discussed in Chapter 1 Section 4.5.5, some defensins have been reported as allergenic. However, TGAS118 is not a known tomato allergen (for known tomato allergens, see Chapter 1 Section 3.4.2). Some defensins cause toxicity when applied to mammalian cells *in vitro*. However, this exposure pathway differs

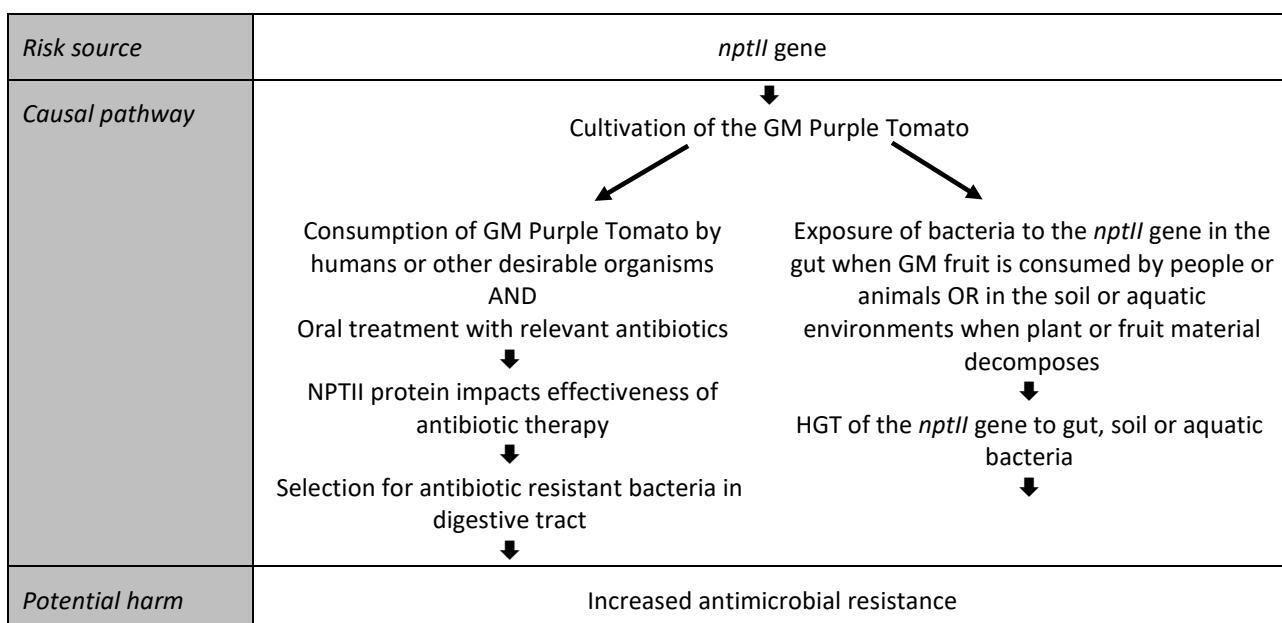
from ingestion where proteins are denatured and digested. Also, defensins are expressed in a wide range of plants, including in parts of plants that people consume e.g. wheat seeds. They are also being investigated for clinical anti-fungal applications.

206. Therefore, given that TGAS118 is an endogenous tomato defensin that is already expressed to some degree in tomato fruit and that plant defensins are expressed in many other plant species, it is not expected that the increased expression of the *tgas118* defensin in the GM Purple Tomato will lead to increased toxicity or allergenicity in people or other desirable organisms, however this is an area of some uncertainty. This expectation that upregulation of *tgas118* does not pose a harm has been confirmed by people in the US handling GM plant material and consuming GM Purple Tomato fruit without any reported ill effects (see Chapter 1 Section 6.2).

2.4.1.4 Conclusion

207. Risk Scenario 1 is not identified as a substantive risk for an increase in toxicity or allergenicity in people, or in toxicity in other desirable organisms because the introduced *Rosea1* and *Delila* genes are from the edible snapdragon, the introduced proteins and their pigment products are not expected to be toxic or allergenic, the *nptII* gene and its product are present in other GM food and feed plants without causing adverse effects in people and other organisms, a food safety assessment has been conducted by FSANZ, tomato pollen is not wind borne, and expression of *Rosea1* and *Delila* is limited to the ripening fruit. Therefore, this risk could not be greater than negligible and does not warrant further detailed assessment.

2.4.2 Risk Scenario 2



2.4.2.1 Risk source

208. The source of potential harm for this postulated risk scenario is the *nptII* gene in the GM Purple Tomato.

2.4.2.2 Causal pathway

Activity of NPTII in mammalian gut on relevant antibiotics

209. As discussed in Risk Scenario 1, people may consume the GM Purple Tomato fruit and other desirable organisms may consume the GM Purple Tomato fruit or vegetative tissues. This part of the scenario focusses on humans and other mammals as these are the species that would receive the relevant antibiotics. As the expression of *nptII* is under the control of a constitutive promoter, it is expected that the NPTII protein would be produced throughout the plant.

210. If the NPTII protein resists digestion and has activity in the digestive tract, it may reduce the effectiveness of any oral antibiotics consumed by the person or animals. If the antibiotic is rendered less

effective by NPTII this could increase selective pressure for the development of antibiotic resistance in the gut bacteria.

211. As discussed in Chapter 1 Section 5.6, of the antibiotics that NPTII confers resistance to, only neomycin and gentamicin are approved for use in veterinary and human medicine in Australia. For the NPTII protein in the gut to come into contact with the antibiotics it would need to be orally administered. Aminoglycoside antibiotics have poor absorption in the GI tract and are usually injected or administered topically. Several products containing neomycin are approved for oral administration to animals in Australia, including feed additive powders and oral suspensions (APVMA, 2024). Gentamicin products approved for veterinary use in Australia are predominately injected or used topically ([APVMA PubCRIS database](#), accessed 7 August 2025). All neomycin products approved for human use in Australia are either for topical or ophthalmic use, not taken orally, and the gentamicin products are either used as a part of orthopaedic cement or given as an intramuscular or intravenous injection ([ARTG](#), accessed 7 August 2025).

212. NPTII is rapidly inactivated in simulated mammalian gastric juice (Fuchs et al., 1993). Therefore, under normal digestion, it would be expected that the NPTII protein would be degraded before it could inactivate the corresponding antibiotic, negating any possible interference with oral administration of the antibiotic.

Horizontal gene transfer of the *nptII* gene to microorganisms

213. Horizontal gene transfer (HGT) is the stable acquisition and heritability of genetic material that was not inherited from a parent organism. It should be noted that HGT per se is not considered an adverse outcome, but may be a link in a chain of events that may lead to an adverse outcome. A recent paper from staff at the OGTR outlines regulatory considerations for horizontal gene transfer from genetically modified plants (Philips et al., 2022). Key considerations from the paper and any newer publications will be discussed here.

214. For HGT to occur from a GM plant to a microorganism in the environment, the following factors need to be considered:

- Are naturally occurring bacteria likely to come into contact with the genetic material from the GMO?
- Can the genetic material be transferred to naturally occurring bacteria?
- Is the genetic material already present in the environment?
- Is there a selective advantage for microorganisms to contain the *nptII* gene?

215. As the GM Purple Tomato is proposed for commercial release it is expected that naturally occurring bacteria could come into contact with the genetic material from the GMO, whether in the digestive system after consumption of GM Purple Tomato fruit or exposure of soil or aquatic microorganisms to decaying GM Purple Tomato plant material.

216. When considering the exposure of microorganisms to the *nptII* gene, it is important to consider the proportion of the introduced DNA in comparison to the total tomato genome as this influences the likelihood of the gene being transferred to a microorganism. The tomato genome is approximately 800 Mbp (Su et al., 2021) while *nptII* is approximately 800 bp (Ghanem, 2011). Therefore, as tomato is a diploid organism (i.e. that has two copies of *nptII*), the *nptII* gene is approximately 0.0002% of the GM Purple Tomato genome.

217. The main methods of HGT to microorganisms are conjugation (direct transfer of DNA between microorganisms), transfer via a phage, and uptake of naked DNA from the environment (reviewed in Good et al., 2025). Of the possible microorganisms for HGT to occur from GM plants, bacteria are considered the most likely recipients because they possess several mechanisms facilitating DNA uptake and there are multiple ways that they can have physical proximity with plants and/or their DNA. Scenarios in which bacteria may come into contact with DNA from the GM Purple Tomato include in the gastrointestinal tract of humans and animals, in the soil and in an aquatic environment.

218. Philips et al. (2022) includes an extensive review of the potential for DNA from a GM plant to undergo HGT to bacteria and the findings can be summarised as:

- HGT from GM plants to bacteria has been rarely reported, likely due to the low proportion of introduced DNA in GM plants, the requirement for naked DNA to remain intact long enough for HGT to occur, and the low frequency of HGT from plants to microorganisms.
- Food preparation, cooking and digestion affect the integrity of DNA, so it is unlikely that an intact gene could participate in HGT in the digestive tract.
- DNA from GM plants could make its way to the aquatic environment and become available for HGT should the DNA maintain integrity.
- There is no evidence in the published literature of HGT from a GM plant to soil bacteria under field conditions.

219. Since the literature review for that paper, there have been several relevant studies published that discuss HGT to microorganisms. Three studies assessed soil bacteria around GM crops, specifically GM soybean (Oh et al., 2021), GM papaya (Thongrak et al., 2025), and GM maize (Jang et al., 2025). None of these studies found evidence of HGT of the introduced genes in the GMOs into soil bacteria. Regarding the potential for HGT from GM plant material to bacteria in the digestive tract, one new study reported HGT of 2 transgenic antibiotic resistance genes (including *nptII*) from a GM plant diet to gut bacteria in rats (Oraby et al., 2022). There are several limitations in this study regarding interpreting the potential for HGT to bacteria, including not testing for the full-length antibiotic resistance genes or confirming if antibiotic resistance genes were integrated into bacterial genomes or plasmids. In a rebuttal submission to Mexico regarding their measures for GM corn, the US included an analysis of the Oraby et al. (2022) paper, noting multiple experimental design issues that made conclusions difficult to interpret, including whether the bacteria in the rats digestive system naturally contained the antibiotic resistance genes (United States of America, 2024). Another study of HGT conducted a phylogenetic analysis of 1163 genomes from bacteria, 147 genomes from vascular plants and 456 genomes from other organisms was used to identify 16 genes that were likely transferred from plants to bacteria. This indicates that, while HGT from plants to bacteria is a very rare event, it is possible on a broader evolutionary scale.

220. Given this information, it is considered that HGT of introduced genes from GM plants to bacteria is theoretically possible but is highly unlikely to occur.

221. As discussed in Chapter 1 Section 4.1.3, expression of the *nptII* gene is controlled by the NOS promoter. If the *nptII* gene was to be transferred to a bacterium along with the associated NOS promoter, this eukaryotic promoter would not function in the bacteria and the *nptII* gene would not be expressed.

222. If there is an advantage for microorganisms to contain the *nptII* gene, then this may exert selective pressure in favour of containing the *nptII* gene. Aminoglycoside antibiotics were originally isolated from microorganisms of either the *Streptomyces* genus (e.g. neomycin) or the *Micromonospora* genus (e.g. gentamicin) (reviewed in Serio et al., 2018). Therefore, it is expected that bacteria would come into contact with these microorganisms in the environment, but the selective pressure is not expected to be high based on random, localised interactions. Use of aminoglycoside antibiotics in humans and animals is discussed in the next section.

223. While not as prevalent in the environment as some other antibiotic resistance genes including *nptIII*, the *nptII* gene is found in bacteria around the world. In Australia, among 45 *E.coli* genomes sampled from pig faeces, 1 was positive for *nptII* (Messele et al., 2023). A study of soils in 100 fields in Austria where GMOs had never been grown showed 6% of the fields were positive for *nptII* DNA (Woegerbauer et al., 2015). Among paediatric and general hospitals in Iran, 14.4% of gram negative bacteria isolates contained the *nptII* gene, most of these being *Pseudomonas aeruginosa* (Azimi et al., 2022). In another study in Iranian hospitals, *nptII* was found in 61.8% of *P. aeruginosa* isolates (Aghazadeh et al., 2013). In China, of 205 *E. coli* strains collected from 9 different hospitals, 20 strains were positive for *nptII* (Xiao and Hu, 2012). Therefore, the *nptII* gene is already present in naturally occurring bacteria in the environment and available for HGT to occur.

2.4.2.3 Potential harm

224. The *nptII* gene is a frequently used selectable marker in GM plants, with 150 commercial GM plant events approved in at least one country worldwide ([ISAAA GM Approval database](#), accessed 7 August

2025). In Australia, approvals for the commercial release of GMOs containing *nptII* include GM banana (DIR 199), GM chrysanthemum (DIR 190), and GM cotton (DIR 124). There have been no adverse effects reported from these releases.

225. Antimicrobial resistance is being monitored in Australia, with antibiotic resistance being of particular concern for human and animal health, potentially leading to longer hospital stays for people, higher medical and veterinary costs, and possibly death ([Australian Government Antimicrobial Resistance website](#), accessed 7 August 2025). The *nptII* gene confers resistance to several aminoglycoside antibiotics, including neomycin and gentamicin. As discussed in Chapter 1 Section 5.6, aminoglycoside antibiotics are globally recognised as a critically important class of antibiotics. Of the antibiotics that *nptII* confers resistance to, only neomycin and gentamicin are approved for both human and veterinary use in Australia while the others are approved for neither. In Australia, the Australian Strategic and Technical Advisory Group on Antimicrobial Resistance (ASTAG) has listed neomycin individually as Low Importance in Australia and gentamicin as Medium Importance. Therefore, an increase in antibacterial resistance to neomycin or gentamicin is considered to be a potential harm.

226. As discussed in Section 2.4.2.2, the causal pathways which may lead to increased antibacterial resistance are highly unlikely to occur. Therefore, the presence of the *nptII* gene in GM Purple Tomato plants is highly unlikely to lead to any of the potential harms listed above.

2.4.2.4 Conclusion

227. Risk Scenario 2 is not identified as a substantive risk because the NPTII protein is rapidly degraded in the digestive system and HGT of the *nptII* gene from a GM plant to bacteria is considered to be highly unlikely and the gene is already readily available in naturally occurring bacteria for HGT to occur. Therefore, this risk could not be greater than negligible and does not warrant further detailed assessment.

2.4.3 Risk Scenario 3

<i>Risk source</i>	The GM Purple Tomato
<i>Causal pathway</i>	<p style="text-align: center;">↓</p> <p style="text-align: center;">Cultivation of the GM Purple Tomato</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Persistence of the GM seeds in cultivated areas or dispersal of the GM Purple Tomato to nature reserves or intensive use areas</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Establishment of population of volunteer GM Purple Tomato in cultivated areas, nature reserves or intensive use areas</p> <p style="text-align: center;">↓</p>
<i>Potential harm</i>	<p>Increased allergenicity or toxicity in people or increased toxicity to other desirable organisms</p> <p style="text-align: center;">OR</p> <p>Reduced establishment or yield of desirable agricultural crops</p> <p style="text-align: center;">OR</p> <p>Reduced establishment or yield of desirable plants in the environment</p> <p style="text-align: center;">OR</p> <p>Reduced utility or quality of the environment</p> <p style="text-align: center;">OR</p> <p>Increased reservoir for pests or pathogens</p>

2.4.3.1 Risk source

228. The source of potential harm for this postulated risk scenario is the GM Purple Tomato.

2.4.3.2 Causal pathway

229. As per Risk Scenario 1, the GM Purple Tomato may be grown intentionally for commercial production or in the home garden.

230. If presence of the introduced genetic changes was to provide the GM Purple Tomato plants with a significant selective advantage over non-GM tomatoes, this may lead to persistence of the GM Purple Tomatoes in areas where they are cultivated (whether commercially or in the home garden). It is noted that persistence of healthy tomato plants may a desirable outcome from tomato cultivation and persistence during tomato cultivation is not considered an adverse effect. However, if the GM Purple Tomato plants were dispersed outside the area they are cultivated in, and were able to establish and persist in environments, such as conservation and natural environments or intensive use areas, this may give rise to adverse outcomes. This assessment assumes that GM Purple Tomato plants have the potential to be present in all current and potential tomato growing areas in Australia and home gardens due to deliberate planting.

231. If GM tomato seed persisted in agricultural areas or the home garden after harvest and volunteer GM tomato plants emerged, it is not expected that expression of the introduced *Delila* and *Rosea1* genes would result in increased persistence of GM volunteers or reduced ability to control volunteer tomato plants. As discussed in Chapter 1 Sections 3.5, 5.1 and 5.2, tomatoes are sensitive to extremes in abiotic conditions, including temperature and moisture, are susceptible to a variety of fungal, viral and bacterial diseases, are poor competitors with agricultural weeds, and are not considered to be a weed in Australia. Anthocyanins are known to play a role in plant responses to a range of environmental stresses (Chapter 1, Section 4.1.1.1). As the *Delila* and *Rosea1* genes are under the control of a fruit ripening specific promoter and increasing anthocyanin in the fruit only, it is not expected that the GM Purple Tomato plants would have improved stress tolerance and ability to persist in the environment compared to non-GM tomatoes. Increased anthocyanin content is thought to contribute to the decreased susceptibility of the GM fruit to *Botrytis* infection. Again, as the increased anthocyanin production is limited to the ripening GM fruit, it is not expected that the GM Purple tomato plants would have altered susceptibility to pests and diseases.

232. The GM Purple Tomato could be dispersed in the environment by several mechanisms, including through consumption of fruit by animals, home composting and disposal of waste from commercial production and processing. It should be noted that as this is an application for commercial release, if approved, dealings with the GM Purple Tomato could occur across Australia and dispersal of the GM Purple Tomato into the environment is not considered an adverse outcome, but may be a step in a chain of events that may lead to an adverse outcome.

233. Producing fruit is an important mechanism by which plants can have their seeds dispersed by animals. While there is limited information available on the potential for animals to disperse tomato seeds, the information that is available indicates that tomato seeds can pass through the digestive system intact and viable (Chapter 1 Section 3.5). As discussed in Risk Scenario 1, there is no strong evidence that the GM Purple Tomato fruit would be more attractive to fruit eating animals than non-GM tomato fruit, so it is expected that GM Purple Tomato seeds would be dispersed by fruit eating animals at a similar rate as non-GM tomatoes.

234. Tomato pomace, a byproduct of commercial processing which is approximately 60% seed and 40% peel, may be used as a livestock feed, composted, or disposed of in landfill. The 2 main processing methods are hot break, where chopped tomatoes are heated to 90-95°C which is used for more viscous products such as tomato paste, and cold break, where chopped tomatoes are processed at ambient temperature or up to 65°C which is used for less viscous products such as tomato juice (reviewed in Shao et al., 2013). While it is likely that these processing methods will significantly affect the viability of the tomato seeds, it is possible that some may still be viable in the resulting pomace.

235. Vegetative material from the GM Purple Tomatoes may be composted or disposed of in landfill. As discussed in Chapter 1 Section 3.2, tomato plants grow readily from cuttings and have a high capacity for the formation of adventitious roots (roots that form at the base of cuttings, stems in contact with soil etc.), so it is possible that new tomato plants may grow from this waste vegetative material.

236. The *nptII* antibiotic resistance gene is under the control of a constitutive promoter and is expected to be expressed throughout the GM Purple Tomato plant. The *nptII* gene is only expected to provide a selective advantage to the GMO plant in the presence of neomycin, kanamycin and structurally related

antibiotics. These antibiotics are used for medical and veterinary purposes, and are not used on tomato crops or on other plants.

237. The potential increase in TGAS118 defensin protein concentration in the fruit of the GM Purple Tomato may confer resistance to tomato diseases, such as specific fungal diseases. If the GM Purple Tomato seeds also have increased expression of the defensin they may be able to germinate in the presence of those specific fungal tomato pathogens, however the expression of TGAS118 is normal in other tissues and will not provide the GM Purple Tomato plants with an advantage over non-GM tomato plants.

238. Abiotic conditions, such as temperature, water availability and nutrient availability are the main limiting factors in the development of both GM and non-GM tomato plants. If the GM Purple Tomatoes were to spread into the environment, the purple fruit phenotype is easily identifiable in mature fruiting plants. It is expected that the GM volunteers would be controlled by standard management practice for control of non-GM tomato volunteers, such as uprooting or use of herbicides (Chapter 1, Section 3.5).

2.4.3.3 Potential harm

239. If the GM Purple Tomato remained as a volunteer population in agricultural areas or the home garden after cultivation, or was able to spread and persist outside in the environment, the postulated harms are increased toxicity or allergenicity to people, increased toxicity to other desirable animals, reduced establishment or yield of desirable agricultural crops or other desirable plants in the environment, reduced utility or quality of the environment, and an increased reservoir for pests or pathogens.

240. As discussed in Risk scenario 1, no substantiative risk was identified for increased toxicity or allergenicity of the GMO for people or increased toxicity to other desirable organisms.

241. If the GM Purple Tomato plants were to spread, establish and persist beyond growing areas, this could impact the environment, e.g. it could reduce establishment or yield of desirable agricultural crops; reduce establishment of desirable native vegetation; reduce utility of roadsides, drains, channels and other intensive use areas; or reduce the quality of the biotic environment by providing a reservoir for pathogens or pests.

242. If the GM Purple Tomato is more attractive to pollinators, then they may preferentially go to the GM Purple Tomato, changing their pollination habits at the expense of other desirable plants. Bees are the primary pollinators of tomatoes and are known to show a preference for purple flowers (Reverte et al., 2016), but it is noted that the GM Purple Tomato has the standard yellow flowers seen in non-GM tomatoes (Chapter 1 Section 4.5.7). Therefore, the GM Purple Tomato flowers are not expected to change the behaviours of usual tomato pollinators.

243. As discussed in Section 2.4.3.2, the causal pathways which may lead to increased spread and persistence of the GM Purple Tomato are highly unlikely to occur. Therefore, the presence of the introduced genetic changes in GM Purple Tomato plants is highly unlikely to lead to any of the potential harms listed above.

244. As discussed in Chapter 1, Section 6.2, the GM Purple Tomato has been commercially released in the United States since 2024, both as fruit sold in grocery stores and seeds sold to home gardeners, with no adverse effects reported from this release.

2.4.3.4 Conclusion

245. Risk Scenario 3 is not identified as a substantive risk because tomatoes have limited ability to establish outside cultivation due to abiotic and biotic factors, the introduced genes are not expected to affect the GMO's ability to respond to these limiting factors, and the GM tomato is not expected to be harmful. Therefore, this risk could not be greater than negligible and does not warrant further detailed assessment.

2.4.4 Risk Scenario 4

<i>Risk source</i>	The GM Purple Tomato
<i>Causal pathway</i>	<p style="text-align: center;">↓</p> <p style="text-align: center;">Cultivation of the GM Purple Tomato</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Outcrossing with sexually compatible plants</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Establishment of populations of hybrid GM plants expressing the introduced genes in the environment</p> <p style="text-align: center;">↓</p>
<i>Potential harm</i>	<p>Increased allergenicity or toxicity in people or increased toxicity to other desirable organisms OR Reduced establishment or yield of desirable agricultural crops OR Reduced establishment or yield of desirable plants in the environment OR Reduced utility or quality of the environment OR Increased reservoir for pests or pathogens</p>

2.4.4.1 Risk source

246. The source of potential harm for this postulated risk scenario is the GM Purple Tomato.

2.4.4.2 Causal pathway

247. As per Risk Scenario 1, the GM Purple Tomato may be grown intentionally for commercial production or in the home garden and may cross with sexually compatible species. It should be noted that vertical gene flow per se is not considered an adverse outcome, but may be a step in a chain of events that may lead to an adverse outcome.

248. The GM Purple Tomato is sexually compatible with other varieties of cultivated tomatoes. As discussed in Chapter 1, Section 4.5.1, the GMO has been bred into several different tomato backgrounds. The applicant has indicated that while most breeding activities are expected to take place outside Australia, some may take place in Australia. Therefore, the GMO may be intentionally hybridised with non-GM tomato varieties by the applicant.

249. Home gardeners may also intentionally cross the GM Purple Tomato with other tomato varieties (e.g. [The Seed Collection – A Home Gardener’s Guide to Breeding Your Own Tomatoes](#), accessed 4 August 2025).

250. As discussed in Chapter 1, Section 3.2, tomatoes are self-compatible and primarily self-pollinating, with this pollination facilitated by physical vibrating the tomato flowers. In a natural setting there are very low levels of outcrossing. It is not expected that the introduced genes would alter the pollen dispersal characteristics of the GM Purple Tomato and no changes to flower morphology have been noted by the applicant (Chapter 1 Section 4.5.7). Therefore, outcrossing between the GM Purple Tomato and non-GM tomato varieties would be expected to occur at similarly low levels as between non-GM tomato varieties.

251. As discussed in Chapter 1, Section 5.4, of the wild tomato varieties that *S. lycopersicum* is sexually compatible with, only *S. pimpinellifolium* (also known as the currant tomato) is present in Australia. It is not cultivated commercially but seed packets can be purchased by home gardeners. While unlikely, it is possible that the GM Purple Tomato could hybridise with *S. pimpinellifolium* in a home garden setting if they are both grown simultaneously and close together. Some *S. pimpinellifolium* plants display a more exerted stigma which improves outcrossing. In the laboratory, *S. pimpinellifolium* has been successfully crossed bidirectionally (both as the female and male in the cross) with *S. lycopersicum* (Sharma et al., 2008). In

addition, the weedy *S. lycopersicum* var. *cerasiforme* found in Peru and Ecuador may be a hybrid of *S. lycopersicum* with *S. pimpinellifolium* (Blanca et al., 2012; Nesbitt and Tanksley, 2002; Ranc et al., 2008).

252. If unintentional hybridisation was to occur, the insert containing the introduced genes is inherited in a dominant Mendelian manner (Chapter 1 Section 4.5.3), so hybrids with purple fruit could be easily visually identified when fruiting.

2.4.4.3 Potential harm

253. If the GM Purple Tomato were to hybridise with sexually compatible species, including other tomatoes or the wild relative currant tomato, the postulated harms are increased toxicity or allergenicity to people, increased toxicity to other desirable animals, reduced establishment or yield of desirable agricultural crops or other desirable plants in the environment, reduced utility or quality of the environment, and an increased reservoir for pests or pathogens.

254. As discussed in Risk Scenario 1, no substantiative risk was identified for increased toxicity or allergenicity of the GMO for people or increased toxicity to other desirable organisms. Similarly, in hybrids between the GM plants and sexually compatible plants, the same considerations as discussed in Risk Scenario 1 would apply.

255. As discussed in Risk Scenario 3, the GM Purple Tomato is not expected to be more able to spread and persist in the environment than non-GM tomatoes. Similarly, in the event of hybridisation with sexually compatible plants, the introduced genetic modifications are not expected to increase the ability of GM hybrid(s) to spread and persist, or to change their susceptibility to the abiotic and biotic factors that limit the survival of tomatoes in the environment. Also, standard weed management practices for tomato volunteers in agricultural settings would control GM hybrids.

2.4.4.4 Conclusion

256. Risk Scenario 4 is not identified as a substantive risk because tomatoes have limited ability to outcross and any hybrids between the GMO and sexually compatible species are not expected to show increased levels of toxicity or allergenicity, or increased ability to spread and persist in the environment. Therefore, this risk could not be greater than negligible and does not warrant further detailed assessment.

Section 3 Uncertainty

257. Uncertainty is an intrinsic property of risk analysis and is present in all aspects of risk analysis. This is discussed in detail in the Regulator's Risk Analysis Framework document.

258. Uncertainty is addressed by approaches such as balance of evidence, conservative assumptions, and applying risk management measures that reduce the potential for risk scenarios involving uncertainty to lead to harm. If there is residual uncertainty that is important for estimating the level of risk, the Regulator will take this uncertainty into account in making decisions.

259. Uncertainty can arise from a lack of experience with the GMO. For this GMO, over 8000 GM Purple Tomato plants have been grown in the US and over 29 tonnes of fruit have been sold in US grocery stores (Chapter 1, Section 6.2). Relevant information from this release have been considered in relevant sections of Chapter 1 of this document and in the risk scenarios. No unintended effects or adverse events have been reported as part of those releases.

260. Although there is some uncertainty about the expression of a defensin gene (see Chapter 1 Section 4.5.5), the upregulation has been assessed as posing negligible risks and, overall, the level of uncertainty in this risk assessment is considered low and does not impact on the overall estimate of risk.

261. Post release review (PRR) will be also used to address uncertainty regarding future changes to knowledge about the GMO or the receiving environment (Chapter 3, Section 4). PRR is typically required for commercial releases of GMOs, which generally do not have limited duration.

Section 4 Risk evaluation

262. Risk is evaluated against the objective of protecting the health and safety of people and the environment to determine the level of concern and, subsequently, the need for controls to mitigate or reduce risk. Risk evaluation may also aid consideration of whether the proposed dealings should be authorised, need further assessment, or require collection of additional information.

263. Factors used to determine which risks need treatment may include:

- risk criteria
- level of risk
- uncertainty associated with risk characterisation
- interactions between substantive risks.

264. Four risk scenarios were postulated whereby the proposed dealings might give rise to harm to people or the environment. The level of risk for each risk scenario was considered negligible, considering both the short and long term. The principal reasons for these conclusions are summarised in Table 8.

265. Therefore, risks to the health and safety of people, or the environment, from the proposed release of the GM Purple Tomato into the environment are considered to be negligible. The *Risk Analysis Framework* (OGTR, 2013), which guides the risk assessment and risk management process, defines negligible risks as risks of no discernible concern with no present need to invoke actions for mitigation. Therefore, no additional controls are required to treat these negligible risks. Hence, the Regulator considers that the dealings involved in this proposed release do not pose a significant risk to either people or the environment.

Chapter 3 Risk management plan

Section 1 Background

266. Risk management is used to protect the health and safety of people and to protect the environment by controlling or mitigating risk. The risk management plan addresses risks evaluated as requiring treatment and considers limits and controls proposed by the applicant, as well as general risk management measures. The risk management plan informs the Regulator's decision-making process and is given effect through licence conditions.

267. Under Section 56 of the Act, the Regulator must not issue a licence unless satisfied that any risks posed by the dealings proposed to be authorised by the licence are able to be managed in a way that protects the health and safety of people and the environment.

268. All licences are subject to 3 conditions prescribed in the Act. Section 63 of the Act requires that each licence holder inform relevant people of their obligations under the licence. The other statutory conditions allow the Regulator to maintain oversight of licensed dealings: Section 64 requires the licence holder to provide access to premises to OGTR inspectors and Section 65 requires the licence holder to report any information about risks or unintended effects of the dealing to the Regulator on becoming aware of them. Matters related to the ongoing suitability of the licence holder must also be reported to the Regulator.

269. The licence is also subject to any conditions imposed by the Regulator. Examples of the matters to which conditions may relate are listed in Section 62 of the Act. Licence conditions can be imposed to limit and control the scope of the dealings and to manage risk to people or the environment. In addition, the Regulator has extensive powers to monitor compliance with licence conditions under Section 152 of the Act.

Section 2 Risk treatment measures for substantive risks

270. The risk assessment of risk scenarios listed in Chapter 2 concluded that there are negligible risks to people and the environment from the proposed commercial release of the GM Purple Tomato. These risk scenarios were considered in the context of the scale of the proposed release (Chapter 1, Section 2) and the receiving environment (Chapter 1, Section 6), and considering both the short and the long term. The risk evaluation concluded that no specific risk treatment measures are required to treat these negligible risks.

Section 3 General risk management

271. All DIR licences issued by the Regulator contain conditions that relate to general risk management. These include conditions relating to:

- applicant suitability
- testing methodology
- identification of the persons or classes of persons covered by the licence
- reporting structures
- access for the purpose of monitoring for compliance.

3.1 Applicant suitability

272. In making a decision whether or not to issue a licence, the Regulator must have regard to the suitability of the applicant to hold a licence. Under Section 58 of the Act, matters that the Regulator must take into account include:

- any relevant convictions of the applicant
- any revocation or suspension of a relevant licence or permit held by the applicant under a law of the Commonwealth, a State or a foreign country and
- the capacity of the applicant to meet the conditions of the licence.

273. Based on information submitted by the applicant and records held by the OGTR, the Regulator considers the applicant suitable to hold a licence. The licence includes a requirement for the licence holder to inform the Regulator of any information that would affect their suitability.

3.2 Testing methodology

274. The applicant is required to provide a method to the Regulator for the reliable detection of the GMO. As part of the application, the applicant supplied appropriate detection methods to detect the DNA insert in the GMO. Therefore, a requirement to provide detection methods is not included in the licence conditions.

3.3 Identification of the persons or classes of persons covered by the licence

275. Any person, including the licence holder, can conduct any permitted dealing with the GMO.

3.4 Reporting requirements

276. The licence requires the licence holder to immediately report any of the following to the Regulator:

- any additional information regarding risks to the health and safety of people or the environment associated with the dealings
- any contraventions of the licence by persons covered by the licence and
- any unintended effects of the field trial.

277. The licence holder is also obliged to submit an Annual Report containing any information required by the licence.

278. There are also provisions that would enable the Regulator to obtain information from the licence holder relating to the progress of the commercial release (see Section 4, below).

3.5 Monitoring for compliance

279. The Act stipulates, as a condition of every licence, that a person who is authorised by the licence to deal with a GMO, and who is required to comply with a condition of the licence, must allow inspectors and other persons authorised by the Regulator to enter premises where a dealing is being undertaken for the purpose of monitoring or auditing the dealing.

280. In cases of non-compliance with licence conditions, the Regulator may instigate an investigation to determine the nature and extent of non-compliance. The Act provides for criminal sanctions of large fines and/or imprisonment for failing to abide by the legislation, conditions of the licence or directions from the Regulator, especially where significant damage to the health and safety of people or the environment could result.

Section 4 Post release review

281. Paragraph 10 of the Regulations requires the Regulator to consider the short and the long term when assessing risks. The Regulator takes account of the likelihood and impact of an adverse outcome over the foreseeable future and does not disregard a risk on the basis that an adverse outcome might only occur in the longer term. However, as with any predictive process, accuracy is often greater in the shorter rather than longer term.

282. The Regulator engages in ongoing oversight of licences to take account of future findings or changes in circumstances. This ongoing oversight is achieved through post release review (PRR) activities. The 3 components of PRR are:

- adverse effects reporting system (Section 4.1)
- requirement to collect additional specific information (Section 4.2)
- review of the RARMP (Section 4.3).

283. The outcomes of these PRR activities may result in no change to the licence or could result in the variation, cancellation or suspension of the licence.

4.1 Adverse effects reporting system

284. Any member of the public can report adverse experiences/effects resulting from an intentional release of a GMO to the OGTR through the Free-call number (1800 181 030), mail (MDP 54 – GPO Box 9848, Canberra ACT 2601) or via email to the OGTR inbox (ogtr@health.gov.au). Reports can be made at any time on any DIR licence. Credible information would form the basis of further investigation and may be used to inform a review of a RARMP (see Section 4.3 below) as well as the RARMPs of future applications involving similar GMOs.

4.2 Requirement to collect additional specific information

285. Collection of additional specific information on an intentional release provides a mechanism for ‘closing the loop’ in the risk analysis process and for verifying findings of the RARMP.

286. This may involve monitoring specific indicators of harm that have been identified in the risk assessment. The term ‘specific indicators of harm’ does not mean that it is expected that harm would necessarily occur if a licence was issued. Instead, it refers to measurement endpoints which are expected to change should the authorised dealings result in harm. The licence holder is required to monitor these specific indicators of harm as mandated by the licence.

287. The triggers for this component of PRR may include risk estimates greater than negligible or significant uncertainty in the risk assessment.

288. The characterisation of the risk scenarios discussed in Chapter 2 did not identify any risks greater than negligible. Therefore, they were not considered substantive risks that warranted further detailed assessment. No specific indicators of harm have been identified in this RARMP for application DIR-218. However, specific indicators of harm may also be identified during later stages, through either of the other components of PRR.

289. Conditions have also been included in the licence to allow the Regulator to request further information from the licence holder about any matter to do with the release, including research to verify predictions of the risk assessment.

4.3 Review of the RARMP

290. The third component of PRR is the review of RARMPs after a commercial/general release licence is issued. Such a review would take into account any relevant new information, including any changes in the context of the release, to determine if the findings of the RARMP remained current. The timing of the review would be determined on a case-by-case basis and may be triggered by findings from either of the other components of PRR, or by relevant new scientific information or be undertaken after the authorised dealings have been conducted for some time. If the review findings justified either an increase or decrease in the initial risk estimate(s) or identified new risks to people or to the environment that require management, this could lead to changes to the risk management plan and licence conditions.

Section 5 Conclusions of the RARMP

291. The risk assessment concludes that the proposed commercial release of GM Purple Tomato plants poses negligible risks to the health and safety of people or the environment as a result of gene technology.

The risk management plan concludes that these negligible risks do not require specific risk treatment measures. However, general conditions are imposed to ensure that there is ongoing oversight of the release.

References

Adams, S. (2001). Effect of Temperature on the Growth and Development of Tomato Fruits. *Annals of Botany* 88, 869-877.

Aghazadeh, M., Rezaee, M.A., Nahaei, M.R., Mahdian, R., Pajand, O., Saffari, F., Hassan, M., *et al.* (2013). Dissemination of aminoglycoside-modifying enzymes and 16S rRNA methylases among *acinetobacter baumannii* and *Pseudomonas aeruginosa* isolates. *Microb Drug Resist* 19, 282-288.

Ahmad, N., Chamas, A., and Trethowan, R. (2023). Reproductive Biology of *Solanum orbiculatum* ssp. *orbiculatum*, an Australian Endemic Bush Tomato. *Agronomy* 13.

Akiyama, R., Nakayasu, M., Umemoto, N., Kato, J., Kobayashi, M., Lee, H.J., Sugimoto, Y., *et al.* (2021). Tomato E8 Encodes a C-27 Hydroxylase in Metabolic Detoxification of alpha-Tomatine during Fruit Ripening. *Plant Cell Physiol* 62, 775-783.

Albert, N.W., Butelli, E., Moss, S.M.A., Piazza, P., Waite, C.N., Schwinn, K.E., Davies, K.M., *et al.* (2021). Discrete bHLH transcription factors play functionally overlapping roles in pigmentation patterning in flowers of *Antirrhinum majus*. *New Phytol* 231, 849-863.

APVMA (2024). Neomycin - Review Technical Report. (Australian Pesticides and Veterinary Medicines Authority).

Ariyarathna, R.A.I.S., Weerasena, S.L., and Beneragama, C.K. (2020). Deleterious Effects of Storage Environmental Conditions on The Seed Quality of Two Varieties of Tomato (*Solanum lycopersicum* L.) Stored in Triple Laminated Aluminum Packing in Sri Lanka. *International Journal of Applied Sciences and Biotechnology* 8, 437-447.

ASCIA (2024). Oral Allergy Syndrome - Frequently Asked Questions. (Australasian Society of Clinical Immunology and Allergy).

ASTAG (2018). Importance Ratings and Summary of Antibacterial Uses in Human and Animal Health in Australia, Version 1.0 (2018). (Australian Strategic and Technical Advisory Group on Antimicrobial Resistance (ASTAG)).

Australian Processing Tomato Research Council (2024). Australian Processing Tomato Research Council Inc. - Annual Industry Survey.

Azimi, L., Armin, S., Samadi Kafil, H., Abdollahi, N., Ghazvini, K., Hasanzadeh, S., Shahraki Zahedani, S., *et al.* (2022). Evaluation of phenotypic and genotypic patterns of aminoglycoside resistance in the Gram-negative bacteria isolates collected from pediatric and general hospitals. *Mol Cell Pediatr* 9, 2.

Bammer, G., and Smithson, M. (2008). Uncertainty and risk: Multidisciplinary perspectives (London, UK: Earthscan).

Barrera-Gil, J., Huertas, R., Rambla, J.L., Granell, A., and Salinas, J. (2016). Tomato plants increase their tolerance to low temperature in a chilling acclimation process entailing comprehensive transcriptional and metabolic adjustments. *Plant Cell Environ* 39, 2303-2318.

Barry, C.S., and Pandey, P. (2009). A survey of cultivated heirloom tomato varieties identifies four new mutant alleles at the green-flesh locus. *Molecular Breeding* 24, 269-276.

Bashir, M.A., Alvi, A.M., Khan, K.A., Rehmani, M.I.A., Ansari, M.J., Atta, S., Ghamh, H.A., *et al.* (2018). Role of pollination in yield and physicochemical properties of tomatoes (*Lycopersicon esculentum*). *Saudi J Biol Sci* 25, 1291-1297.

Baxter, A.A., Richter, V., Lay, F.T., Poon, I.K., Adda, C.G., Veneer, P.K., Phan, T.K., *et al.* (2015). The Tomato Defensin TPP3 Binds Phosphatidylinositol (4,5)-Bisphosphate via a Conserved Dimeric Cationic Grip Conformation To Mediate Cell Lysis. *Mol Cell Biol* 35, 1964-1978.

Berry, T., and Bewley, J.D. (1992). A Role for the Surrounding Fruit Tissues in Preventing the Germination of Tomato (*Lycopersicon esculentum*) Seeds : A Consideration of the Osmotic Environment and Abscisic Acid. *Plant Physiol* 100, 951-957.

Blanca, J., Canizares, J., Cordero, L., Pascual, L., Diez, M.J., and Nuez, F. (2012). Variation revealed by SNP genotyping and morphology provides insight into the origin of the tomato. *PLoS One* 7, e48198.

Brog, Y.M., Osorio, S., Yiche, Y., Alseekh, S., Bensal, E., Kochevenko, A., Zamir, D., *et al.* (2019). A *Solanum neorickii* introgression population providing a powerful complement to the extensively characterized *Solanum pennellii* population. *Plant J* 97, 391-403.

Burney, P.G., Potts, J., Kummeling, I., Mills, E.N., Clausen, M., Dubakiene, R., Barreales, L., *et al.* (2014). The prevalence and distribution of food sensitization in European adults. *Allergy* 69, 365-371.

Butelli, E., Titta, L., Giorgio, M., Mock, H.P., Matros, A., Peterek, S., Schijlen, E.G., *et al.* (2008). Enrichment of tomato fruit with health-promoting anthocyanins by expression of select transcription factors. *Nat Biotechnol* 26, 1301-1308.

Cappellini, F., Marinelli, A., Toccaceli, M., Tonelli, C., and Petroni, K. (2021). Anthocyanins: From Mechanisms of Regulation in Plants to Health Benefits in Foods. *Front Plant Sci* 12, 748049.

Chensom, S., Okumura, H., and Mishima, T. (2019). Primary Screening of Antioxidant Activity, Total Polyphenol Content, Carotenoid Content, and Nutritional Composition of 13 Edible Flowers from Japan. *Prev Nutr Food Sci* 24, 171-178.

Cheung, A.Y., McNellis, T., and Piekos, B. (1993). Maintenance of Chloroplast Components during Chromoplast Differentiation in the Tomato Mutant Green Flesh. *Plant Physiol* 101, 1223-1229.

Cirillo, V., D'Amelia, V., Esposito, M., Amitrano, C., Carillo, P., Carpato, D., and Maggio, A. (2021). Anthocyanins are Key Regulators of Drought Stress Tolerance in Tobacco. *Biology (Basel)* 10.

Clark, A.J., and Brinkley, T. (2001). Risk management: for climate, agriculture and policy. (Canberra, Australia: Commonwealth of Australia).

Constable, F., Chambers, G., Penrose, L., Daly, A., Mackie, J., Davis, K., Rodoni, B., *et al.* (2019). Viroid-infected Tomato and Capsicum Seed Shipments to Australia. *Viruses* 11.

Cosi, V., and Gadermaier, G. (2023). The Role of Defensins as Pollen and Food Allergens. *Curr Allergy Asthma Rep* 23, 277-285.

Cowan, P.E. (1992). Analysis of the characteristics of fruit eaten by possums, *Trichosurus vulpecula*, in New Zealand. *New Zealand Journal of Zoology* 19, 45-52.

Cui, J., Jiang, N., Meng, J., Hou, X., Yang, G., and Luan, Y. (2018). Identification and characterization of defensin genes conferring *Phytophthora infestans* resistance in tomato. *Physiological and Molecular Plant Pathology* 103, 28-35.

de Vetten, N., Quattrocchio, F., Mol, J., and Koes, R. (1997). The an11 locus controlling flower pigmentation in petunia encodes a novel WD-repeat protein conserved in yeast, plants, and animals. *Genes Dev* 11, 1422-1434.

Deikman, J., Kline, R., and Fischer, R.L. (1992). Organization of Ripening and Ethylene Regulatory Regions in a Fruit-Specific Promoter from Tomato (*Lycopersicon esculentum*). *Plant Physiol* 100, 2013-2017.

Delaney, B., Goodman, R.E., and Ladics, G.S. (2018). Food and feed safety of genetically engineered food crops. *Toxicological Sciences* 162, 361-371.

Department of Agriculture and Food Western Australia (2005). Harmful garden plants in Western Australia. Report No. Bulletin 4641. (Perth: Department of Primary Industries and Regional Development Western Australia).

Ebert, P.R., Ha, S.B., and An, G. (1987). Identification of an essential upstream element in the nopaline synthase promoter by stable and transient assays. *Proceedings of the National Academy of Sciences of the United States of America* 84, 5745-5749.

Fang, J. (2014). Bioavailability of anthocyanins. *Drug Metab Rev* 46, 508-520.

Finkina, E.I., Shevchenko, O.V., Fateeva, S.I., Tagaev, A.A., and Ovchinnikova, T.V. (2024). Antifungal Plant Defensins as an Alternative Tool to Combat Candidiasis. *Plants (Basel)* 13.

Foolad, M.R., Subbiah, P., and Zhang, L. (2007). Common QTL affect the rate of tomato seed germination under different stress and nonstress conditions. *Int J Plant Genomics* 2007, 97386.

Friedman, M. (2004). Analysis of biologically active compounds in potatoes (*Solanum tuberosum*), tomatoes (*Lycopersicon esculentum*), and jimson weed (*Datura stramonium*) seeds. *Journal of Chromatography A* 1054, 143-155.

Friedman, M., Fitch, T.E., and Yokoyama, W.E. (2000). Lowering of plasma LDL cholesterol in hamsters by the tomato glycoalkaloid tomatine. *Food Chem Toxicol* 38, 549-553.

Fuchs, R.L., Ream, J.E., Hammond, B.G., Naylor, M.W., Leimgruber, R.M., and Berberich, S.A. (1993). Safety assessment of the neomycin phosphotransferase II (NPTII) protein. *Bio/technology* 11, 1543-1547.

Fullelove, G., Wright, R., Meurant, N., Barnes, J., and O'Brien, R. (1998). Tomato information kit (Nambour, Qld: Agrilink).

Gallo, M., Naviglio, D., and Ferrara, L. (2014). Nasunin, an antioxidant anthocyanin from eggplant peels, as natural dye to avoid food allergies and intolerances.

Georgiady, M.S., Whitkus, R.W., and Lord, E.M. (2002). Genetic analysis of traits distinguishing outcrossing and self-pollinating forms of currant tomato, *Lycopersicon pimpinellifolium* (Jusl.) Mill. *Genetics* 161, 333-344.

Ghanem, S. (2011). Cloning of the nptII gene of *Escherichia coli* and construction of a recombinant strain harboring functional recA and nptII antibiotic resistance. *Genet Mol Res* 10, 1445-1454.

Giovannoni, J.J. (2004). Genetic regulation of fruit development and ripening. *The Plant Cell* 16, S170-S180.

Glover, B.J., and Martin, C. (2012). Anthocyanins. *Current Biology* 22, R147-R150.

Goncalves, A.C., Nunes, A.R., Falcao, A., Alves, G., and Silva, L.R. (2021). Dietary Effects of Anthocyanins in Human Health: A Comprehensive Review. *Pharmaceuticals (Basel)* **14**.

Good, B.H., Bhatt, A.S., and McDonald, M.J. (2025). Unraveling the tempo and mode of horizontal gene transfer in bacteria. *Trends Microbiol* **33**, 853-865.

Guadalupe, G.M., Raul, A.C., Javier, L.C., Lorena, D., and Aline, S.T. (2022). Longevity of preserved *Solanum lycopersicum* L. seeds: physicochemical characteristics. *Physiol Mol Biol Plants* **28**, 505-516.

Guan, L., Tayengwa, R., Cheng, Z.M., Peer, W.A., Murphy, A.S., and Zhao, M. (2019). Auxin regulates adventitious root formation in tomato cuttings. *BMC Plant Biol* **19**, 435.

Hayes, K.R. (2004). Ecological implications of GMOs: robust methodologies for ecological risk assessment. Best practice and current practice in ecological risk assessment for genetically modified organisms. (Tasmania, Australia: CSIRO Division of Marine Research).

Hazell, R.J., Sam, K., Sreekar, R., Yama, S., Koagouw, W., Stewart, A.J.A., and Peck, M.R. (2023). Bird preferences for fruit size, but not color, vary in accordance with fruit traits along a tropical elevational gradient. *Ecol Evol* **13**, e9835.

Heguy, J.M., Cassinero, C.A., Fadei, J.G., Asmus, J., Taylor, S.J., and DePeters, E.J. (2015). Nutrient composition and total-tract apparent digestibility of whole tomato seeds by sheep. *The Professional Animal Scientist* **31**, 462-466.

Hirai, T., Kim, Y.W., Kato, K., Hiwasa-Tanase, K., and Ezura, H. (2011). Uniform accumulation of recombinant miraculin protein in transgenic tomato fruit using a fruit-ripening-specific E8 promoter. *Transgenic Res* **20**, 1285-1292.

Horneburg, B., Becker, H.C., and Léon, J. (2018). Spontaneous outcrossing in tomato depends on cultivar and environment and varies between individual flowers. *Plant Breeding* **137**, 638-643.

Hort Innovation (2024). Australian Horticulture Statistics Handbook 2023/24 - All Vegetables.

Huang, W., Hu, N., Xiao, Z., Qiu, Y., Yang, Y., Yang, J., Mao, X., *et al.* (2022). A molecular framework of ethylene-mediated fruit growth and ripening processes in tomato. *Plant Cell* **34**, 3280-3300.

Hughes, N.M., Morley, C.B., and Smith, W.K. (2007). Coordination of anthocyanin decline and photosynthetic maturation in juvenile leaves of three deciduous tree species. *New Phytol* **175**, 675-685.

Hurst, R.D., Lyall, K.A., Wells, R.W., Sawyer, G.M., Lomiwes, D., Ngametua, N., and Hurst, S.M. (2020). Daily Consumption of an Anthocyanin-Rich Extract Made From New Zealand Blackcurrants for 5 Weeks Supports Exercise Recovery Through the Management of Oxidative Stress and Inflammation: A Randomized Placebo Controlled Pilot Study. *Front Nutr* **7**, 16.

Igwe, E.O., Charlton, K.E., and Probst, Y.C. (2019). Usual dietary anthocyanin intake, sources and their association with blood pressure in a representative sample of Australian adults. *J Hum Nutr Diet* **32**, 578-590.

Jang, J., Hur, H.G., Sadowsky, M.J., Byappanahalli, M.N., Yan, T., and Ishii, S. (2017). Environmental *Escherichia coli*: ecology and public health implications-a review. *J Appl Microbiol* **123**, 570-581.

Jang, Y.J., Oh, S.D., Hong, J.K., Park, J.C., Lee, S.K., Chang, A., Yun, D.W., *et al.* (2025). Impact of genetically modified herbicide-resistant maize on rhizosphere bacterial communities. *GM Crops Food* **16**, 186-198.

Kapoor, L., Simkin, A.J., George Priya Doss, C., and Siva, R. (2022). Fruit ripening: dynamics and integrated analysis of carotenoids and anthocyanins. *BMC Plant Biol* 22, 27.

Keese, P. (2008). Risks from GMOs due to horizontal gene transfer. *Environmental Biosafety Research* 7, 123-149.

Keese, P.K., Robold, A.V., Myers, R.C., Weisman, S., and Smith, J. (2014). Applying a weed risk assessment approach to GM crops. *Transgenic Research* 23, 957-969.

Khoo, H.E., Azlan, A., Tang, S.T., and Lim, S.M. (2017). Anthocyanidins and anthocyanins: colored pigments as food, pharmaceutical ingredients, and the potential health benefits. *Food Nutr Res* 61, 1361779.

Khusnutdinov, E., Sukhareva, A., Panfilova, M., and Mikhaylova, E. (2021). Anthocyanin Biosynthesis Genes as Model Genes for Genome Editing in Plants. *Int J Mol Sci* 22.

Klaassen, C.D., and Watkins, J.B., eds. (2010). *Casarett & Doull's Essentials of Toxicology*, 2nd edn (New York, USA: McGraw-Hill).

Kondo, Y., and Urisu, A. (2009). Oral allergy syndrome. *Allergol Int* 58, 485-491.

Kozukue, N., Han, J., Lee, K., and Friedman, M. (2004). Dehydrotomatine and α -tomatine content in tomato fruits and vegetative plant tissues. *Journal of Agricultural and Food Chemistry* 52, 2079-2083.

Kumar, M., Chandran, D., Tomar, M., Bhuyan, D.J., Grasso, S., Sá, A.G.A., Carciofi, B.A.M., et al. (2022). Valorization Potential of Tomato (*Solanum lycopersicum* L.) Seed: Nutraceutical Quality, Food Properties, Safety Aspects, and Application as a Health-Promoting Ingredient in Foods. *Horticulturae* 8.

Kurokawa, N., Hirai, T., Takayama, M., Hiwasa-Tanase, K., and Ezura, H. (2013). An E8 promoter-HSP terminator cassette promotes the high-level accumulation of recombinant protein predominantly in transgenic tomato fruits: a case study of miraculin. *Plant Cell Rep* 32, 529-536.

Kurze, E., Lo Scalzo, R., Campanelli, G., and Schwab, W. (2018). Effect of tomato variety, cultivation, climate and processing on Sola I 4, an allergen from *Solanum lycopersicum*. *PLoS One* 13, e0197971.

Laude, S. (2023). Competitiveness of tomato (*Lycopersicon esculentum* Mill.) with weeds at various nitrogen doses and weed free periods. *IOP Conference Series: Earth and Environmental Science* 1253, 012030.

Lee, C.-L., Coyle, H.M., Carita, E., Ladd, C., Yang, N.C.S., Palmbach, T.M., Hsu, I.C., et al. (2006). DNA Analysis of Digested Tomato Seeds in Stomach Contents. *The American Journal of Forensic Medicine and Pathology* 27, 121-125.

Lee, C.-L., Coyle, H.M., Palmbach, T.M., Hsu, I.C., and Lee, H.C. (2005). DNA Analysis of Ingested Tomato and Pepper Seeds. *The American Journal of Forensic Medicine and Pathology* 26, 330-333.

Li, C., Yang, Z., Zhang, C., Luo, J., Zhang, F., and Qiu, R. (2023). Effects of Nitrogen Application in Recovery Period after Different High Temperature Stress on Plant Growth of Greenhouse Tomato at Flowering and Fruiting Stages. *Agronomy* 13.

Li, J., Xian, J., Zhang, S., An, Y., Li, N., Zhou, D., Sun, S., et al. (2025). Influence of pigment composition on antioxidant capacity of different tomato (*Solanum lycopersicum* L.). *Lwt* 224.

Lim, W., Miller, R., Park, J., and Park, S. (2014). Consumer sensory analysis of high flavonoid transgenic tomatoes. *J Food Sci* 79, S1212-1217.

Lis, K., and Bartuzi, Z. (2023). Plant Food Dyes with Antioxidant Properties and Allergies—Friend or Enemy? *Antioxidants* 12.

Liu, H., Ouyang, B., Zhang, J., Wang, T., Li, H., Zhang, Y., Yu, C., *et al.* (2012). Differential modulation of photosynthesis, signaling, and transcriptional regulation between tolerant and sensitive tomato genotypes under cold stress. *PLoS One* 7, e50785.

Luo, J., Butelli, E., Hill, L., Parr, A., Niggeweg, R., Bailey, P., Weisshaar, B., *et al.* (2008). AtMYB12 regulates caffeoyl quinic acid and flavonol synthesis in tomato: expression in fruit results in very high levels of both types of polyphenol. *Plant J* 56, 316-326.

Ma, M., Taylor, P.W.J., Chen, D., Vaghefi, N., and He, J.Z. (2023). Major Soilborne Pathogens of Field Processing Tomatoes and Management Strategies. *Microorganisms* 11.

Ma, Y., Ma, X., Gao, X., Wu, W., and Zhou, B. (2021). Light Induced Regulation Pathway of Anthocyanin Biosynthesis in Plants. *Int J Mol Sci* 22.

Martin, C., and Butelli, E. (2025). The Purple Tomato Story; From Laboratory Bench to the Consumer. *ACS Food Sci Technol* 5, 19-28.

Martin, C., Prescott, A., Mackay, S., Bartlett, J., and Vrijlandt, E. (1991). Control of anthocyanin biosynthesis in flowers of *Antirrhinum majus*. *Plant J* 1, 37-49.

Martín, J., Kuskoski, E.M., Navas, M.J., and Asuero, A.G. (2017). Antioxidant Capacity of Anthocyanin Pigments. In *Flavonoids - From Biosynthesis to Human Health*.

Mathews, H., Clendennen, S.K., Caldwell, C.G., Liu, X.L., Connors, K., Matheis, N., Schuster, D.K., *et al.* (2003). Activation tagging in tomato identifies a transcriptional regulator of anthocyanin biosynthesis, modification, and transport. *Plant Cell* 15, 1689-1703.

Mazzucato, A., Daniela, W., Bernini, R., Picarella, M., Santangelo, E., Ruiu, F., Francesca, T., *et al.* (2013). Novel phenotypes related to the breeding of purple-fruited tomatoes and effect of peel extracts on human cancer cell proliferation. *Plant physiology and biochemistry : PPB / Societe francaise de physiologie vegetale*.

McCormack. J (2004). *TOMATO SEED PRODUCTION* An organic seed production manual for seed growers in the Mid-Atlantic and Southern U.S.

McDougall, S., Watson, A., Stodart, B., Napier, T., Kelly, G., Troldahl, D., and Tesoriero, L. (2013). Tomato, capsicum, chilli and eggplant: a field guide for the identification of insect pests, beneficials, diseases and disorders in Australia and Cambodia, A.C.f.I.A. Research, ed.

Menconi, J., Perata, P., and Gonzali, S. (2023). Novel R2R3 MYB transcription factors regulate anthocyanin synthesis in Aubergine tomato plants. *BMC Plant Biol* 23, 148.

Menconi, J., Perata, P., and Gonzali, S. (2024). In pursuit of purple: anthocyanin biosynthesis in fruits of the tomato clade. *Trends Plant Sci* 29, 589-604.

Mendez, E., Moreno, A., Colilla, F., Pelaez, F., Limas, G.G., Mendez, R., Soriano, F., *et al.* (1990). Primary structure and inhibition of protein synthesis in eukaryotic cell-free system of a novel thionin, gamma-hordothionin, from barley endosperm. *Eur J Biochem* 194, 533-539.

Mes, P.J., Boches, P., Myers, J.R., and Durst, R. (2008). Characterization of Tomatoes Expressing Anthocyanin in the Fruit. *Journal of the American Society for Horticultural Science* 133, 262-269.

Mesa, T., Polo, J., Arabia, A., Caselles, V., and Munne-Bosch, S. (2022). Differential physiological response to heat and cold stress of tomato plants and its implication on fruit quality. *J Plant Physiol* 268, 153581.

Messele, Y.E., Trott, D.J., Hasoon, M.F., Veltman, T., McMeniman, J.P., Kidd, S.P., Djordjevic, S.P., *et al.* (2023). Phylogenetic Analysis of *Escherichia coli* Isolated from Australian Feedlot Cattle in Comparison to Pig Faecal and Poultry/Human Extraintestinal Isolates. *Antibiotics (Basel)* 12.

Naing, A.H., Ai, T.N., Lim, K.B., Lee, I.J., and Kim, C.K. (2018). Overexpression of Rosea1 From Snapdragon Enhances Anthocyanin Accumulation and Abiotic Stress Tolerance in Transgenic Tobacco. *Front Plant Sci* 9, 1070.

Naing, A.H., Park, K.I., Ai, T.N., Chung, M.Y., Han, J.S., Kang, Y.W., Lim, K.B., *et al.* (2017). Overexpression of snapdragon Delila (Del) gene in tobacco enhances anthocyanin accumulation and abiotic stress tolerance. *BMC Plant Biol* 17, 65.

Nesbitt, T.C., and Tanksley, S.D. (2002). Comparative sequencing in the genus *Lycopersicon*. Implications for the evolution of fruit size in the domestication of cultivated tomatoes. *Genetics* 162, 365-379.

Nikoloudakis, N., Pappi, P., Markakis, E.A., Charova, S.N., Fanourakis, D., Paschalidis, K., Delis, C., *et al.* (2020). Structural Diversity and Highly Specific Host-Pathogen Transcriptional Regulation of Defensin Genes Is Revealed in Tomato. *International Journal of Molecular Sciences* 21.

Nkongho, R.N., Ndam, L.M., Akoneh, N.N., Tongwa, Q.M., Njilar, R.M., Agbor, D.T., Sama, V., *et al.* (2023). Vegetative propagation of F1 tomato hybrid (*Solanum lycopersicum* L.) using different rooting media and stem-nodal cuttings. *Journal of Agriculture and Food Research* 11.

Novak, W.K., and Haslberger, A.G. (2000). Substantial equivalence of antinutrients and inherent plant toxins in genetically modified novel foods. *Food and Chemical Toxicology* 38, 473-483.

OECD (2008). Consensus document on compositional considerations for new varieties of tomato: key food and feed nutrients, toxicants and allergens. Report No. 17. (Paris: OECD Environment, Health and Safety Publications).

OECD (2017). Safety Assessment of Transgenic Organisms in the Environment, Volume 7: OECD Consensus Documents. Report No. 9789264250451. (Paris: Organisation for Economic Co-operation and Development).

OGTR (2013). Risk Analysis Framework 2013, 4th edn (Canberra: Office of the Gene Technology Regulator).

Oh, S.-D., Jang, Y.-J., Park, S.-Y., Lee, K., Lee, S.-K., Yun, D.-W., Suh, S., *et al.* (2021). Assessment of the effect on soil microbial communities of genetically modified soybean and a hybrid from crossing with wild soybean. *Plant Biotechnology Reports* 15.

OIE (2021). OIE List of Antimicrobial Agents of Veterinary Importance. (Paris, France: World Organisation for Animal Health (OIE)).

Oraby, H.A.-S., Aboul-Maaty, N.A.-F., Al-Sharawi, H.A., and Osman, N.M. (2022). Horizontal transfer of antibiotic resistance genes into microflora and blood cells in rats fed on GM-diet. *Bulletin of the National Research Centre* 46, 268.

Outchkourov, N.S., Karlova, R., Holscher, M., Schrama, X., Blilou, I., Jongedijk, E., Simon, C.D., *et al.* (2018). Transcription Factor-Mediated Control of Anthocyanin Biosynthesis in Vegetative Tissues. *Plant Physiol* *176*, 1862-1878.

Panda, S., Chappell-Maor, L., Alejandro de Haro, L., Jozwiak, A., Gharat, S.A., Kazachkova, Y., Cai, J., *et al.* (2025). Molecular mechanisms driving the unusual pigmentation shift during eggplant fruit development. *Plant Commun* *6*, 101321.

Paulsen, E., Christensen, L.P., and Andersen, K.E. (2012). Tomato contact dermatitis. *Contact Dermatitis* *67*, 321-327.

Peralta, I., Spooner, D., and Knapp, S. (2008). Taxonomy of wild tomatoes and their relatives (Solanum sect. Lycopersicoides, sect. Juglandifolia, sect. Lycopersicon; Solanaceae). *Systematic Botany Monographs* *84*, 186 pp.

Philips, J.G., Martin-Avila, E., and Robold, A.V. (2022). Horizontal gene transfer from genetically modified plants - Regulatory considerations. *Frontiers in Bioengineering and Biotechnology* *10*.

Pressman, E., Peet, M., and Pharr, D.M. (2002). The Effect of Heat Stress on Tomato Pollen Characteristics is Associated with Changes in Carbohydrate Concentration in the Developing Anthers. *Annals of Botany* *90*, 631-636.

Qiu, Z., Wang, X., Gao, J., Guo, Y., Huang, Z., and Du, Y. (2016). The Tomato Hoffman's Anthocyaninless Gene Encodes a bHLH Transcription Factor Involved in Anthocyanin Biosynthesis That Is Developmentally Regulated and Induced by Low Temperatures. *PLoS One* *11*, e0151067.

Quirós, C.F., and Marcías, A. (1978). Natural Cross Pollination and Pollinator Bees of the Tomato in Celaya, Central Mexico1. *HortScience* *13*, 290-291.

Ranc, N., Munos, S., Santoni, S., and Causse, M. (2008). A clarified position for *Solanum lycopersicum* var. *cerasiforme* in the evolutionary history of tomatoes (solanaceae). *BMC Plant Biol* *8*, 130.

Reeves, A. (1973). Observation on Natural Outcropping in the Tomato (*Lycopersicon Esculentum* L.) in Northwest Arkansas. *Journal of the Arkansas Academy of Science* *27*.

Reverte, S., Retana, J., Gomez, J.M., and Bosch, J. (2016). Pollinators show flower colour preferences but flowers with similar colours do not attract similar pollinators. *Ann Bot* *118*, 249-257.

Rick, C.M., Uhlig, J.W., and Jones, A.D. (1994). High alpha-tomatine content in ripe fruit of Andean *Lycopersicon esculentum* var. *cerasiforme*: developmental and genetic aspects. *Proc Natl Acad Sci U S A* *91*, 12877-12881.

Roldan, M.V.G., Engel, B., de Vos, R.C.H., Vereijken, P., Astola, L., Groenenboom, M., van de Geest, H., *et al.* (2014). Metabolomics reveals organ-specific metabolic rearrangements during early tomato seedling development. *Metabolomics* *10*, 958-974.

Ryckeboer, J., Cops, S., and Coosemans, J. (2002). The Fate of Plant Pathogens and Seeds During Anaerobic Digestion and Aerobic Composting of Source Separated Household Wastes. *Compost Science & Utilization* *10*, 204-216.

Sainju, U.M., Dris, R., and Singh, B. (2003). Mineral nutrition of tomato.

Sakamura, S., Watanabe, S., and Obata, Y. (1963). The Structure of the Major Anthocyanin in Eggplant. *Agr Biol Chem* *27*, 663-665.

Sapir, M., Oren-Shamir, M., Ovadia, R., Reuveni, M., Evenor, D., Tadmor, Y., Nahon, S., *et al.* (2008). Molecular Aspects of Anthocyanin fruit Tomato in Relation to high pigment-1. *Journal of Heredity* 99, 292-303.

Sato, S., Peet, M.M., and Thomas, J.F. (2001). Physiological factors limit fruit set of tomato (*Lycopersicon esculentum* Mill.) under chronic, mild heat stress. *Plant, Cell & Environment* 23, 719-726.

Schnell, J., Steele, M., Bean, J., Neuspiel, M., Girard, C., Dormann, N., Pearson, C., *et al.* (2015). A comparative analysis of insertional effects in genetically engineered plants: considerations for pre-market assessments. *Transgenic Research* 24, 1-17.

Schram, A.W., Jonsson, L.M.V., and Vlaming, P.d. (1983). Identification of Anthocyanins and Intermediates of Anthocyanin Biosynthesis from *Petunia hybrida* Using High Performance Liquid Chromatography. *Zeitschrift für Naturforschung C* 38, 342-345.

Schwarz-Sommer, Z., Davies, B., and Hudson, A. (2003). An everlasting pioneer: the story of *Antirrhinum* research. *Nat Rev Genet* 4, 657-666.

Schwinn, K., Venail, J., Shang, Y., Mackay, S., Alm, V., Butelli, E., Oyama, R., *et al.* (2006). A small family of MYB-regulatory genes controls floral pigmentation intensity and patterning in the genus *Antirrhinum*. *Plant Cell* 18, 831-851.

Sebastian, R.S., Wilkinson Enns, C., Goldman, J.D., Martin, C.L., Steinfeldt, L.C., Murayi, T., and Moshfegh, A.J. (2015). A New Database Facilitates Characterization of Flavonoid Intake, Sources, and Positive Associations with Diet Quality among US Adults. *J Nutr* 145, 1239-1248.

Serio, A.W., Keepers, T., Andrews, L., and Krause, K.M. (2018). Aminoglycoside Revival: Review of a Historically Important Class of Antimicrobials Undergoing Rejuvenation. *EcoSal Plus* 8.

Setlalekgomo, M., and Sesinyi, K. (2014). Seed dispersal by serrated tortoises (*Psammobates oculiferus*) and the effect of their gut passage on seed germination. *Scientific Journal of Animal Science* 3, 252–257.

Shao, D., Atungulu, G.G., Pan, Z., Yue, T., Zhang, A., and Fan, Z. (2013). Characteristics of Isolation and Functionality of Protein from Tomato Pomace Produced with Different Industrial Processing Methods. *Food and Bioprocess Technology* 7, 532-541.

Sharma, A., Zhang, L., Nino-Liu, D., Ashrafi, H., and Foolad, M.R. (2008). A *Solanum lycopersicum* x *Solanum pimpinellifolium* linkage map of tomato displaying genomic locations of R-genes, RGAs, and candidate resistance/defense-response ESTs. *Int J Plant Genomics* 2008, 926090.

Shaw, K.J., Rather, P.N., Hare, R.S., and Miller, G.H. (1993). Molecular genetics of aminoglycoside resistance genes and familial relationships of the aminoglycoside-modifying enzymes. *Microbiological Reviews* 57, 138-163.

Shi, J., Zhao, Y., Zhao, P., Yang, H., Wang, C., Xia, J., Zhao, Z., *et al.* (2024). Preferentially expressed endosperm genes reveal unique activities in wheat endosperm during grain filling. *BMC Genomics* 25, 795.

Skolik, P., Morais, C.L.M., Martin, F.L., and McAinsh, M.R. (2019). Determination of developmental and ripening stages of whole tomato fruit using portable infrared spectroscopy and Chemometrics. *BMC Plant Biol* 19, 236.

Steiner, H.Y., Halpin, C., Jez, J.M., Kough, J., Parrott, W., Underhill, L., Weber, N., *et al.* (2013). Evaluating the potential for adverse interactions within genetically engineered breeding stacks. *Plant Physiology* *161*, 1587-1594.

Story, E.N., Kopec, R.E., Schwartz, S.J., and Harris, G.K. (2010). An update on the health effects of tomato lycopene. *Annu Rev Food Sci Technol* *1*, 189-210.

Stotz, H.U., Spence, B., and Wang, Y. (2009a). A defensin from tomato with dual function in defense and development. *Plant Mol Biol* *71*, 131-143.

Stotz, H.U., Thomson, J.G., and Wang, Y. (2009b). Plant defensins: defense, development and application. *Plant Signal Behav* *4*, 1010-1012.

Su, X., Wang, B., Geng, X., Du, Y., Yang, Q., Liang, B., Meng, G., *et al.* (2021). A high-continuity and annotated tomato reference genome. *BMC Genomics* *22*, 898.

Su, X., Xu, J., Rhodes, D., Shen, Y., Song, W., Katz, B., Tomich, J., *et al.* (2016). Identification and quantification of anthocyanins in transgenic purple tomato. *Food Chem* *202*, 184-188.

Sun, C., Deng, L., Du, M., Zhao, J., Chen, Q., Huang, T., Jiang, H., *et al.* (2020). A Transcriptional Network Promotes Anthocyanin Biosynthesis in Tomato Flesh. *Mol Plant* *13*, 42-58.

Takeda, K. (2006). Blue metal complex pigments involved in blue flower color. *Proc Jpn Acad Ser B Phys Biol Sci* *82*, 142-154.

Tanksley, S.D. (2004). The genetic, developmental, and molecular bases of fruit size and shape variation in tomato. *Plant Cell* *16 Suppl*, S181-189.

Todore, C., Theodore, K., Westcott, D., Suttner, C., and Nilsson, D.E. (2022). The role of detectability in the evolution of avian-dispersed fruit color. *Vision Res* *196*, 108046.

Teo, J., Mohan, R., Zhang, S., Gui, Y., Sng, B.J.R., Jang, I.-C., and Yin, Z. (2022). Optimization of light and temperature in indoor farming to boost anthocyanin biosynthesis and accumulation in Indigo Rose tomato. *Vegetable Research* *2*, 1-11.

The Australia Institute (2024). Grow your own - 2024.

Thongrak, K., Wonnapinij, P., Swatdipong, A., Vuttipongchaikij, S., and Suttangkakul, A. (2025). Assessment of soil bacterial diversity in long-term cultivation of virus-resistant GM papaya. *Plant and Soil* *508*, 499-513.

Tohge, T., Zhang, Y., Peterek, S., Matros, A., Rallapalli, G., Tandron, Y.A., Butelli, E., *et al.* (2015). Ectopic expression of snapdragon transcription factors facilitates the identification of genes encoding enzymes of anthocyanin decoration in tomato. *Plant J* *83*, 686-704.

Umicevic, S., Kukavica, B., Maksimovic, I., Gasic, U., Milutinovic, M., Antic, M., and Misic, D. (2024). Stress response in tomato as influenced by repeated waterlogging. *Front Plant Sci* *15*, 1331281.

United States of America (2024). Mexico - Measures Concerning Genetically Engineered Corn (MX-USA-2023-31-01) - Rebuttal Submission of the United States of America.

USDA (1991). United States Standards for Grades of Fresh Tomatoes, U.S.D.o. Agriculture, ed.

USDA (2022). Guide for Requesting a Regulatory Status Review under 7 CFR part 340, A.a.P.H.I. Service, ed.

Valenta, K., Kalbitzer, U., Razafimandimby, D., Omeja, P., Ayasse, M., Chapman, C.A., and Nevo, O. (2018). The evolution of fruit colour: phylogeny, abiotic factors and the role of mutualists. *Sci Rep* 8, 14302.

van den Heuvel, K.J., Hulzink, J.M., Barendse, G.W., and Wullems, G.J. (2001). The expression of *tgas118*, encoding a defensin in *Lycopersicon esculentum*, is regulated by gibberellin. *J Exp Bot* 52, 1427-1436.

van der Weerden, N.L., Parisi, K., McKenna, J.A., Hayes, B.M., Harvey, P.J., Quimbar, P., Wevrett, S.R., *et al.* (2023). The Plant Defensin *Ppdef1* Is a Novel Topical Treatment for Onychomycosis. *J Fungi (Basel)* 9.

Vernon, L.P., Evett, G.E., Zeikus, R.D., and Gray, W.R. (1985). A toxic thionin from *Pyrularia pubera*: Purification, properties, and amino acid sequence. *Archives of Biochemistry and Biophysics* 238, 18-29.

Virtue, J.G. (2004). SA weed risk management guide. (Adelaide, South Australia: Department of Water, Land and Biodiversity Conservation).

Wahyuningsih, S., Wulandari, L., Wartono, M.W., Munawaroh, H., and Ramelan, A.H. (2017). The Effect of pH and Color Stability of Anthocyanin on Food Colorant. *IOP Conference Series: Materials Science and Engineering* 193, 012047.

Walker, A.R., Davison, P.A., Bolognesi-Winfield, A.C., James, C.M., Srinivasan, N., Blundell, T.L., Esch, J.J., *et al.* (1999). The TRANSPARENT TESTA GLABRA1 locus, which regulates trichome differentiation and anthocyanin biosynthesis in *Arabidopsis*, encodes a WD40 repeat protein. *Plant Cell* 11, 1337-1350.

Wang, H., Sun, S., Zhou, Z., Qiu, Z., and Cui, X. (2020). Rapid analysis of anthocyanin and its structural modifications in fresh tomato fruit. *Food Chem* 333, 127439.

Wangorsch, A., Jamin, A., Foetisch, K., Malczyk, A., Reuter, A., Vierecke, S., Schülke, S., *et al.* (2015). Identification of *Sola* I 4 as *Bet v 1* homologous pathogenesis related-10 allergen in tomato fruits. *Mol Nutr Food Res* 59, 582-592.

Westphal, S., Kempf, W., Foetisch, K., Retzek, M., Vieths, S., and Scheurer, S. (2004). Tomato profilin Lyc e 1: IgE cross-reactivity and allergenic potency. *Allergy* 59, 526-532.

WHO (2024). WHO's List of Medically Important Antimicrobials: a risk management tool for mitigating antimicrobial resistance due to non-human use. (World Health Organization).

Włodarczyk, K., Smolinska, B., and Majak, I. (2022). Tomato Allergy: The Characterization of the Selected Allergens and Antioxidants of Tomato (*Solanum lycopersicum*)-A Review. *Antioxidants (Basel)* 11.

Woegerbauer, M., Zeinzinger, J., Gotsberger, R.A., Pascher, K., Hufnagl, P., Indra, A., Fuchs, R., *et al.* (2015). Antibiotic resistance marker genes as environmental pollutants in GMO-pristine agricultural soils in Austria. *Environmental Pollution* 206, 342-351.

Wu, X., Beecher, G.R., Holden, J.M., Haytowitz, D.B., Gebhardt, S.E., and Prior, R.L. (2006). Concentrations of anthocyanins in common foods in the United States and estimation of normal consumption. *J Agric Food Chem* 54, 4069-4075.

Xiao, Y., and Hu, Y. (2012). The Major Aminoglycoside-Modifying Enzyme AAC(3)-II Found in *Escherichia coli* Determines a Significant Disparity in Its Resistance to Gentamicin and Amikacin in China. *Microbial Drug Resistance* 18, 42-46.

Xu, Y., Liu, X., Huang, Y., Xia, Z., Lian, Z., Qian, L., Yan, S., et al. (2022). Ethylene Inhibits Anthocyanin Biosynthesis by Repressing the R2R3-MYB Regulator SIAN2-like in Tomato. *Int J Mol Sci* 23.

Xu, Z., Mahmood, K., and Rothstein, S.J. (2017). ROS Induces Anthocyanin Production Via Late Biosynthetic Genes and Anthocyanin Deficiency Confers the Hypersensitivity to ROS-Generating Stresses in Arabidopsis. *Plant Cell Physiol* 58, 1364-1377.

Yan, S., Chen, N., Huang, Z., Li, D., Zhi, J., Yu, B., Liu, X., et al. (2020). Anthocyanin Fruit encodes an R2R3-MYB transcription factor, SIAN2-like, activating the transcription of SIMYBATV to fine-tune anthocyanin content in tomato fruit. *New Phytol* 225, 2048-2063.

Zhang, Y., Butelli, E., Alseekh, S., Tohge, T., Rallapalli, G., Luo, J., Kawar, P.G., et al. (2015). Multi-level engineering facilitates the production of phenylpropanoid compounds in tomato. *Nat Commun* 6, 8635.

Zhang, Y., Butelli, E., De Stefano, R., Schoonbeek, H.J., Magusin, A., Pagliarani, C., Wellner, N., et al. (2013). Anthocyanins double the shelf life of tomatoes by delaying overripening and reducing susceptibility to gray mold. *Curr Biol* 23, 1094-1100.

Zhang, Y., Li, Y., Li, W., Hu, Z., Yu, X., Tu, Y., Zhang, M., et al. (2019). Metabolic and molecular analysis of nonuniform anthocyanin pigmentation in tomato fruit under high light. *Hortic Res* 6, 56.

Zhao, S., Blum, J.A., Ma, F., Wang, Y., Borejsza-Wysocka, E., Ma, F., Cheng, L., et al. (2022). Anthocyanin Accumulation Provides Protection against High Light Stress While Reducing Photosynthesis in Apple Leaves. *Int J Mol Sci* 23.

Zheng, X.T., Yu, Z.C., Tang, J.W., Cai, M.L., Chen, Y.L., Yang, C.W., Chow, W.S., et al. (2021). The major photoprotective role of anthocyanins in leaves of *Arabidopsis thaliana* under long-term high light treatment: antioxidant or light attenuator? *Photosynth Res* 149, 25-40.

Appendix A: Summary of submissions on matters relevant to preparation of the consultation RARMP

The Regulator received several submissions from prescribed experts, agencies, and authorities⁴ on matters relevant to preparation of the RARMP. All issues raised in submissions relating to risks to the health and safety of people and the environment were considered. These issues, and where they are addressed in the consultation RARMP, are summarised below.

Submission	Summary of issues raised	Comment
1	<ul style="list-style-type: none"> • Agreed that the following should be included in the RARMP: <ul style="list-style-type: none"> ○ the potential for the GM tomato to be harmful to the environment ○ the potential for the GM tomato to be harmful to people through toxicity or allergenicity ○ the potential for the GM tomato to be harmful to other organisms through toxicity ○ the potential for harm to result from gene flow to other tomatoes ○ whether commercial release is likely to result in changes to agricultural practices that may have an environmental impact. • Advised that the Regulator should further consider the potential risks associated with horizontal gene transfer to the human gut microbiome from widespread consumption. • Advised that the Regulator should further consider the potential risks to consumers from the off-target production of other compounds including toxic alkaloids. • Advised that the Regulator should seek more information related to tomato allergens in the GMO. • Advised that the Regulator should seek more information related to the upregulation of other genes in the GMO. 	<p>These matters have been considered in Chapters 1 and 2 of the RARMP.</p>
2	<p>States that it is not clear from the application what the public benefits are from the proposed approval for purple tomatoes, and that there are already purple style tomatoes in heritage varieties.</p>	<p>Benefits are outside the scope of the Gene Technology legislation. The Regulator's responsibility is</p>

⁴ Prescribed experts, agencies and authorities include GTTAC, State and Territory Governments, relevant local governments, Australian government agencies and the Minister for the Environment.

Submission	Summary of issues raised	Comment
	States that if the application is just for cosmetic or marketing reasons, then does not support it.	to identify and manage risk as a result of gene technology.
3	Provides no comments at this stage and reserves any potential future comments to when the RARMP is prepared.	Noted.
4	<p>Although the tomatoes will be grown in greenhouses, there is still potential for unintended release of modified plant material through waste disposal, or accidents like spilling during transport. Questioned whether waste management protocols should be considered for any sites growing these tomatoes to limit unintended environmental exposure.</p> <p>Questioned whether if the waste goes to a commercial composting site it needs to be separated so modified plant material doesn't contaminate compost.</p>	<p>As this application is for a commercial release of a GM plant, the licence application proposes an ongoing commercial release, with no restrictions on how the GM Purple Tomato is grown or used, and it is therefore assumed that there will be dispersal into the environment. Dispersal and persistence of the GMO is discussed in Risk Scenario 3.</p> <p>As above.</p>
5	<p>Advised that as some people in the community may be concerned about whether a GM plant is safe, it could be good to have clear communication materials about the new tomato and its safety in areas that the tomatoes are going to be grown and sold, while acknowledging that food safety is generally looked after by FSANZ.</p>	<p>As part of the consultation, the public will be notified that the RARMP is open for consultation via our subscriber list, our website, and newspaper advertisement. Other relevant documents including a Questions and Answers will also be made available at this time that includes a plain language summary.</p>
	<p>The application does not comment on whether there is potential for the antimicrobial resistance gene in the GM tomato to spread into the environment and contribute to environmental antimicrobial resistance. Recommends that the applicant provide information in the RARMP on the likelihood of the antimicrobial resistance gene spreading to the environment and any mitigation activities that would be undertaken to minimise the risk.</p>	<p>The potential for increased antimicrobial resistance resulting from horizontal gene transfer of the <i>nptII</i> gene is discussed in Risk Scenario 2.</p>

Submission	Summary of issues raised	Comment
6	<ul style="list-style-type: none"> • What technology was used to introduce the transgenes into the GMO? • Other than the intended insert, were any sequence differences identified in the GMO when compared to the parent? • Are the integration sites of the genes of interest stable over multiple generations? • Is expression of the <i>nptII</i> gene constitutive throughout the GM plant? • Is the protein produced from <i>nptII</i> gene present in the seeds of the GMO? • Is the protein produced from <i>nptII</i> gene present in the fruit of the GMO? • Has kanamycin resistance been reported in bacteria of medical importance in Australia? • What other aminoglycoside antibiotics are used in Australia and has resistance been reported? • Discussed the potential benefits of the GM Purple Tomato as compared to conventional breeding. • In considering risks posed by the GMO, commented that: <ul style="list-style-type: none"> ○ tomatoes present low risk ○ snapdragon flowers are edible ○ horizontal gene transfer between GM plants to bacteria and/or people doesn't appear to be an issue. Noted that most GM canola and some GM cotton that are widely grown in Australia contain the <i>nptII</i> gene. • Although the application states that it is anticipated that the tomatoes will be grown in commercial glasshouses, recommends that the RARMP considers that the GMO, as a seeded fruit, could be grown more widely across Australia. 	<p>The method of genetic modification is discussed in Chapter 1, Section 4.2 of the RARMP.</p> <p>Characterisation of the insert in the GMO is discussed in Chapter 1, Section 4.5.2 of the RARMP.</p> <p>Stability of the insert over multiple generations is discussed in Chapter 1, Section 4.5.3 of the RARMP.</p> <p>The <i>nptII</i> gene and relevant antibiotics are discussed in Chapter 1 Sections 4.1.2 and 5.6, as well as Risk Scenario 2.</p> <p>Benefits are outside the scope of the Gene Technology legislation. The Regulator's responsibility is to identify and manage risk as a result of gene technology.</p> <p>Noted.</p> <p>Cultivation of the GMO by home gardeners and commercial sale of seed packets has been considered as part of the risk context (see Chapter 1, Section 5.3.2 of the RARMP).</p>

Submission	Summary of issues raised	Comment
7	<ul style="list-style-type: none"> • Discussed the intended purpose of the GM Purple Tomato, including the availability of dietary purple anthocyanin • Commented that <ul style="list-style-type: none"> ○ the anthocyanin genes are well understood, and the pigments are a normal part of the diet ○ the product appears to have minimal impact in terms of GMO spread once in the food chain, as while it will be possible for plants to be spread by animal and human consumption, this is based on the seed being able to survive in the gut and excreted. 	<p>Benefits are outside the scope of the Gene Technology legislation. The Regulator's responsibility is to identify and manage risk as a result of gene technology.</p>

Appendix B: Summary of submissions from prescribed experts, agencies and authorities on the consultation RARMP

The Regulator received a number of submissions from prescribed experts, agencies and authorities on the consultation RARMP. All issues raised in submissions that related to risks to the health and safety of people and the environment were considered in the context of the currently available scientific evidence and were used in finalising the RARMP that formed the basis of the Regulator's decision to issue the licence. Advice received is summarised below.

Submission	Summary of issues raised	Comment
1	<p>Notes that previous comments on the potential risk of increasing environmental antimicrobial resistance through the commercial release of the GM tomato have been addressed.</p> <p>Does not have any additional advice or comments for the finalisation of the RARMP for DIR 218.</p>	Noted.
2	<p>Were uncertain whether creating novelty tomatoes is a worthwhile use of the technology, while acknowledging that their views on the necessity of this GMO are not relevant to the assessment.</p> <p>Nonetheless, supported OGTR's conclusion that the application poses negligible risk to the health and safety of people or the environment.</p> <p>Expect that the relevant national industry bodies, along with other relevant regulators such as DAFF will work together to ensure that the introduction of GM purple tomatoes does not adversely affect supply chains or trade issues that fall outside the scope of the Gene Technology legislation.</p>	Noted.
3	<p>Agrees with the findings of the RARMP, noting that the GMO is an authorised food in the United States with commercially produced fruit and seed available to the public since 2024, and that none of the risk scenarios considered in the RARMP were identified as substantive. Also notes that seed importation is a matter for DAFF, and food safety and labelling a matter for FSANZ.</p>	Noted.
4	<p>Accepts that, overall, the application has negligible risks to the health and safety of people and the environment. Are satisfied that the measures taken to manage the short- and long-term risks from the proposal are adequate</p>	Noted.
5	<p>Are satisfied with the RARMP presented, posing very low risk to both humans and the environment. Noted that FSANZ will still need to approve this product for human consumption.</p>	<p>Noted.</p> <p>FSANZ have since approved the use and sale of food derived from the GM Purple Tomato. See the A1333 page on the FSANZ website for further information.</p>

Submission	Summary of issues raised	Comment
6	<p>Agrees that the risk assessment identified all plausible risk scenarios by which the proposed dealings could potentially give rise to risks relating to the health and safety of people or the environment.</p> <p>Agrees with the overall conclusions of the RARMP.</p>	Noted.

Appendix C: Summary of submissions from the public on the consultation RARMP

The Regulator received 15 submissions from the public on the consultation RARMP. The issues raised in these submissions are summarised in the table below. All issues that related to risks to the health and safety of people and the environment were considered in the context of currently available scientific evidence in finalising the RARMP that formed the basis of the Regulator's decision to issue the licence.

Submission	Summary of issues raised	Comment
1	Enquires about any control measures in place for unauthorised production of the GM Purple Tomatoes, specifically in the case where consumers obtain seeds from fruit sold in a supermarket, and then use these to grow plants in unprotected uncontained growing sites.	As this application is for a commercial release of a GM plant, the licence application proposes an ongoing commercial release, with no restrictions on how the GM Purple Tomato is grown or used. It is therefore assumed that there will be dispersal into the environment. Dispersal and persistence of the GMO is discussed in Risk Scenario 3, including the potential for growth by home gardeners. Risk Scenario 3 was assessed as posing negligible risk.
	Enquires about whether the consumption of GM Purple Tomatoes could contribute to increased human resistance to antibiotics via consumption of antibiotic-resistant plants and stated that antibiotic resistance is an existential risk in health and food systems.	The potential for increased antimicrobial resistance resulting from horizontal gene transfer of the <i>nptII</i> gene present in the GM purple Tomato is discussed in Risk Scenario 2. Risk Scenario 2 was assessed as posing negligible risk.
	Requests that OGTR mandate that FSANZ requires labelling of the GM Purple Tomatoes.	FSANZ has existing requirements for GM food labelling. FSANZ have recently approved the use and sale of food derived from the GM Purple Tomato and have stated that food derived from the purple tomato lines will be required to be labelled as 'genetically modified' unless an exemption applies. See the A1333 page and the GM Food Labelling page on the FSANZ website for further information.
2	Strongly disagrees with the proposed release of the GM Purple Tomato and the use of genetically modifying food for human consumption. Expresses concerns about the amount of testing conducted and the safety related to the consumption of the GM Purple Tomato by the public.	Personal views on GMOs are noted. Based on data provided and the scientific literature, the risk assessment concluded that risks to the health and safety of people from the GM Purple Tomato are negligible. FSANZ has regulatory responsibility for food safety assessments in Australia. Human trials are not part of the information required by FSANZ for the

Submission	Summary of issues raised	Comment
3	<p>Opposes the commercial release of the GM Purple Tomato due to inadequate risk assessment and potential long-term environmental consequences that outweigh any benefits. Recommends rejection of this application until knowledge gaps are addressed. Cited the following key concerns:</p> <ul style="list-style-type: none"> Environmental release risks; potential for seed dispersal, uncertainties about whether climate changes could expand the suitable habitat for tomatoes. Inclusion of an antibiotic resistance gene; recent research suggests that horizontal gene transfer may be more likely than the RARMP assumes, <i>nptII</i> confers resistance to critically important antibiotics, selective pressure may drive resistance development. Unintended genetic effects; upregulation of the defensin, doubled α-tomatine and altered flavonoid pathways, limited toxicity testing. 	<p>safety assessment of a GM food. FSANZ have recently approved the use and sale of food derived from the GM Purple Tomato, with their assessment finding that food derived from the GM Purple Tomato is as safe as food from conventional tomatoes already in the Australian and New Zealand food supply. See the A1333 page and Safety assessments of GM foods page on the FSANZ website for further information.</p> <p>As this application is for a commercial release of a GM plant, the licence application proposes an ongoing commercial release, with no restrictions on how the GM Purple Tomato is grown or used. It is therefore assumed that there will be dispersal into the environment. Dispersal and persistence of the GMO is discussed in Risk Scenario 3, including the potential for growth in home gardens. Risk Scenario 3 was assessed as posing negligible risk.</p> <p>The potential for increased antimicrobial resistance resulting from horizontal gene transfer of the <i>nptII</i> gene is discussed in Risk Scenario 2. Risk Scenario 2, which includes recent literature on horizontal gene transfer from plants to microorganisms, was assessed as posing negligible risk.</p> <p>Potential unintended effects have been discussed in Chapter 2 Section 2.1 of the RARMP. The range of unintended effects produced by genetic modification is not likely to be greater than that from accepted traditional breeding techniques such as hybridisation, mutagenesis and somaclonal variation. The only unintended effect that has been identified has been the upregulation of a defensin. This has been considered in Risk Scenario 1 and found to pose negligible risk.</p>

Submission	Summary of issues raised	Comment
	<ul style="list-style-type: none"> Assessment deficiencies; no Australian field studies, inadequate monitoring proposed post-release, whole genome data not provided for independent review Questionable necessity; primarily aesthetic change that does not address genuine agricultural need, non-GM purple tomato varieties are already available, approval of this application would set a precedent for approving modifications without compelling justification. 	<p>The modified trait is limited to the colour of the tomato and is not anticipated to confer an advantage compared to non-GM tomato plants. The RARMP explores the potential for increased dispersal and persistence of the GMO in Risk Scenario 3, which was found to present negligible risk.</p> <p>The licence requires the licence holder to inform the Regulator of any new information about the GMO that may impact the risks to health and safety of people, or to the environment, and a post release review can be conducted by the Regulator at any time.</p>
4	<p>Expressed concerns that:</p> <ul style="list-style-type: none"> The long term data in relation to human health is not available. The danger of it becoming a noxious weed in the environment is considerable. The destruction of natural environmental balance is possible. Once it is released there is no possible way of reversing this decision. 	<p>Based on data provided and the scientific literature, the risk assessment concluded that risks to the health and safety of people from the GM Purple Tomato are negligible. Dispersal and persistence of the GM Purple Tomato in the environment is discussed in Risk Scenario 3 and was assessed as posing negligible risk.</p> <p>FSANZ has regulatory responsibility for food safety assessments in Australia. Human trials are not part of the information required by FSANZ for the safety assessment of a GM food. FSANZ have recently approved the use and sale of food derived from the GM Purple Tomato, with their assessment finding that food derived from the GM Purple Tomato is as safe as food from conventional tomatoes already in the Australian and New Zealand food supply. See the A1333 page and Safety assessments of GM foods page on the FSANZ website for further information.</p>
5	<p>Strongly opposes the release of the GMO purple tomatoes in Australia as it poses unnecessary risks, including the following concerns:</p>	

Submission	Summary of issues raised	Comment
	<ul style="list-style-type: none"> • There is a lack of long term trials in humans or animals to prove they are safe to eat. • Claims that GM foods may significantly increase of the risk of severe allergic reactions in children. • Claims that scientists who produce GM crops have found that unexpected increase of toxicity and other undesirable traits. 	<p>Based on data provided and the scientific literature, the risk assessment concluded that risks to the health and safety of people from the GM Purple Tomato are negligible.</p>
	<ul style="list-style-type: none"> • Lack of labelling laws in Australia or NZ for foods containing GMOs. 	<p>FSANZ has regulatory responsibility for food safety assessments in Australia. FSANZ have recently approved the use and sale of food derived from the GM Purple Tomato, with their assessment finding that food derived from the GM Purple Tomato is as safe as food from conventional tomatoes already in the Australian and New Zealand food supply. See the A1333 page and Safety assessments of GM foods page on the FSANZ website for further information.</p>
	<ul style="list-style-type: none"> • Lack of benefits as anthocyanins are already plentiful in non-GM foods. 	<p>FSANZ has existing requirements for GM food labelling. FSANZ have recently approved the use and sale of food derived from the GM Purple Tomato and have stated that food derived from the purple tomato lines will be required to be labelled as 'genetically modified' unless an exemption applies. See the A1333 page and the GM Food Labelling page on the FSANZ website for further information.</p>
	<ul style="list-style-type: none"> • Introducing GMO foods with all their unknown effects is irresponsible. 	<p>Benefits are outside the scope of the Gene Technology legislation. The Regulator's responsibility is to identify and manage risk as a result of gene technology.</p>
	<ul style="list-style-type: none"> • GMO will be virtually impossible to contain so there may be risks for the environment, including effects on animals, insects and soil micro-organisms. 	<p>Potential unintended effects have been discussed in Chapter 2 Section 2.1 of the RARMP. The range of unintended effects produced by genetic modification is not likely to be greater than that from accepted traditional breeding techniques such as hybridisation, mutagenesis and somaclonal variation. The only unintended effect that has been identified has been the upregulation of a defensin. This has been considered in Risk Scenario 1 and found to pose negligible risk.</p>
	<ul style="list-style-type: none"> • GMO will be virtually impossible to contain so there may be risks for the environment, including effects on animals, insects and soil micro-organisms. 	<p>As this application is for a commercial release of a GM plant, the licence application proposes an ongoing commercial release, with no restrictions</p>

Submission	Summary of issues raised	Comment
6	Opposes the release of genetically engineered tomatoes or food seeds in New Zealand.	Noted.
7	Strongly objects to the release of GM purple tomato.	Noted.
8	<p>Totally opposes the release of the GM purple tomato on the grounds that:</p> <ul style="list-style-type: none"> <li data-bbox="371 781 720 804">• this is an unnecessary food <li data-bbox="371 840 895 929">• they have concerns about the safety of this product both on public health and the environment 	Noted.
	<ul style="list-style-type: none"> <li data-bbox="419 1379 906 1468">• they have concerns about pollen transferring to non-GM tomatoes and impacting the non-GM and organic market <li data-bbox="371 1500 879 1551">• this GM food should be labelled as GM if imported into New Zealand. 	Noted. Segregation and marketing issues are outside the scope of the Gene Technology legislation.
9	Does not support the release into the open environment of any GM horticultural or animal product. Supports natural processes instead.	Noted.

Submission	Summary of issues raised	Comment
10	Does not support the release of the GM purple tomato until the long-term effects of this release on the health and safety of people and the environment are known.	The RARMP concluded that the GM Purple Tomato poses negligible risks. The licence requires the licence holder to inform the Regulator of any new information about the GMO that may impact the risks to health and safety of people, or to the environment, and a post release review can be conducted by the Regulator at any time.
11	Strongly opposes the release of the GM purple tomato based on concerns around the safety of animals and the environment, including chemical resistance.	The potential for harm to come to animals following exposure to the GM Purple Tomato is considered in Risk Scenario 1. Risk Scenario 1 was assessed as posing negligible risk. Issues relating to the use of agricultural chemicals are outside the scope of the Regulator's assessments. The APVMA has regulatory responsibility for agricultural chemicals, including herbicide and insecticide use and the development of herbicide resistance in weeds, in Australia.
12	<p>Is of the view that the proposed commercial release of GM purple tomatoes poses unjustified, unassessed, and unacceptable hazards and risks to Australia's environment, farmers, processors, and markets and recommends the following actions be taken:</p> <ul style="list-style-type: none"> <li data-bbox="377 1264 911 1462">• Conduct an integrated, formal, cross-agency assessment of DIR 218 (OGTR, FSANZ, DAFF, APVMA) to fill regulatory and information gaps, including all impacts such as environmental, health, coexistence, trade, and the public-interest. 	<p>While the Regulator must consider risks to human health and safety and the environment as a result of a genetic modification of a parent organism, other agencies have responsibility for regulating GMOs or genetically modified products as part of a broader or different mandate. Accordingly, the Regulator must consult Commonwealth regulatory agencies prescribed in the Regulations (including FSANZ, APVMA, and DAFF) on all licence applications for dealings involving the intentional release of GMOs to the environment. The OGTR assessment was conducted simultaneously with the FSANZ assessment.</p>
	<ul style="list-style-type: none"> <li data-bbox="377 1855 901 1949">• Reject DIR 218 on the grounds that the RARMP fails to account for plausible pathways to harm and cumulative risks. <li data-bbox="377 1956 901 2048">• Suspend any commercial release, at least until full, independent, long-term trials and studies are conducted under Australian 	The RARMP includes a thorough and critical assessment of data supplied by the applicant, together with a comprehensive review of other relevant national and international scientific literature, and international experience

Submission	Summary of issues raised	Comment
	<p>conditions, including environmental persistence, gene flow, and potential antibiotic-resistance gene transmission.</p> <ul style="list-style-type: none"> Prohibit antibiotic-resistance marker genes from all GM plants proposed for release. Require mandatory Identity Preservation and Coexistence Management Plans for all trial and commercial proposals, incorporating batch traceability and periodic DNA testing. Assess Exclusive Capturable Commercial Benefit (ECCB) and market-concentration risks as part of public-interest evaluation before any licences can be issued. 	<p>with the GMO. The RARMP is finalised following an extensive consultation process involving expert scientists, Australian Government authorities and regulatory agencies, State and Territory Governments, relevant local councils, the Minister for the Environment and the public. The RARMP concludes that the commercial release of this GM tomato poses negligible risks to the health and safety of people or to the environment.</p> <p>The potential for increased antimicrobial resistance is discussed in Risk Scenario 2, and was assessed as posing negligible risk.</p> <p>Marketing and trade issues, including segregation and coexistence regimes, are outside the scope of assessments conducted by the Regulator.</p> <p>Patents, licensing arrangements and economic risks are outside the scope of the Gene Technology legislation.</p> <p>ECCB is considered by FSANZ. An <u>exclusive use permission</u> for novel foods or nutritive substances may be assessed by FSANZ if an applicant expressly applies for it.</p>
13	<p>Does not want GM food.</p> <p>Is concerned about hybridisation of non-GM tomatoes with the GM purple tomato.</p>	<p>Noted.</p> <p>Outcrossing of the GMO with sexually compatible plants, including hybridisation with non-GM tomatoes, is considered in Risk Scenario 4. Risk Scenario 4 was assessed as posing negligible risk.</p> <p>Marketing and trade issues, including segregation and coexistence regimes, are outside the scope of assessments conducted by the Regulator.</p>
14	<p>Concerned about the widespread distribution of genetically engineered tomatoes containing viable seeds resulting in the uncontrolled distribution of the genetic material.</p>	<p>As this application is for a commercial release of a GM plant, the licence application proposes an ongoing commercial release, with no restrictions on how the GM Purple Tomato is grown or used. It is therefore assumed that there will be dispersal into the environment. Dispersal and persistence of the GMO is discussed in Risk Scenario</p>

Submission	Summary of issues raised	Comment
		3, including the potential for growth in home gardens. Risk Scenario 3 was assessed as posing negligible risk.
15	<p>Concerned about the impacts of the release on existing tomato varieties and negative impacts on organic/GE free claims.</p>	Marketing and trade issues, including segregation and coexistence regimes, are outside the scope of assessments conducted by the Regulator.
15	<p>Advises against the approval of the application in its current form as the RARMP does not provide sufficient evidence to support its conclusion of negligible risk, citing the following concerns:</p> <ul style="list-style-type: none"> Commercial greenhouses will not contain the GM pollen, leading to the introduction and establishment of GM material into non-GM agricultural landscapes. 	<p>As this application is for a commercial release of a GM plant, the licence application proposes an ongoing commercial release, with no restrictions on how the GM Purple Tomato is grown or used. It is therefore assumed that there will be dispersal into the environment. Dispersal and persistence of the GMO is discussed in Risk Scenario 3, including the potential for growth in home gardens. Risk Scenario 3 was assessed as posing negligible risk.</p>
15	<ul style="list-style-type: none"> It is a credible risk pathway that enhanced anthocyanin expression could confer a fitness advantage to the GM tomato, increasing its persistence and invasiveness should it escape cultivation. Cites double shelf life of the GM fruit compared to non-GM parent, which could plausibly lead to a greater number of viable seeds in dropped or dispersed fruit. 	<p>While Chapter 1 Section 4.1.1.1 of the RARMP notes that anthocyanins may protect against certain plant stresses, Risk Scenario 2 considers that increased anthocyanin expression appears limited to the ripening fruit of the GMO. It is therefore not expected that the GM Purple Tomato plants would have improved stress tolerance and ability to persist in the environment compared to non-GM tomatoes.</p>
15	<ul style="list-style-type: none"> Regarding anthocyanins in the fruit, there are non-GM tomatoes that have been conventionally bred to have increased anthocyanin production in the fruit. There are no reports that these non-GM purple tomatoes have a fitness advantage compared to their non-purple counterparts and have become environmental weeds. The genetic modification has far-reaching and not fully characterised metabolic consequences, citing the nearly 300-fold increase in the expression of the endogenous plant defensin gene, <i>tgas118</i>, in the fruit. 	<p>Potential unintended effects have been discussed in Chapter 2 Section 2.1 of the RARMP. The range of unintended effects produced by genetic modification is not likely to be greater than that from accepted traditional breeding techniques such as</p>

Submission	Summary of issues raised	Comment
	<ul style="list-style-type: none"> The deliberate, large-scale environmental release of a functional antibiotic resistance gene (<i>nptII</i>) is inconsistent with the precautionary principle, which should be applied where potential consequences are severe. States that since antimicrobial resistance marker genes are now largely considered legacy technology in plant biotechnology, their inclusion in a new commercial release is an avoidable risk to human health. Considers the proposed risk management plan to be inadequate. If the Regulator proceeds toward an approval, the licence must, at a minimum, have conditions that contain the release, prohibit open cultivation, ensure waste material is devitalised, require feral population surveillance, ensure seeds and plant material are traceable from propagation to point of sale, and require a full review of the licence and any environmental monitoring data after a period of no more than five years. 	<p>hybridisation, mutagenesis and somaclonal variation. The only unintended effect that has been identified has been the upregulation of a defensin. This has been considered in Risk Scenario 1 and found to pose negligible risk.</p> <p>The potential for increased antimicrobial resistance resulting from horizontal gene transfer of the <i>nptII</i> gene present in the GM purple Tomato is discussed in Risk Scenario 2. Risk Scenario 2 was assessed as posing negligible risk.</p> <p>This is a licence application for commercial release of the GM Purple Tomato. Since the RARMP concludes that the GMO poses no greater risks to human health and the environment than non-GM tomatoes, no specific licence conditions are required to contain the GM Purple Tomato. Only general conditions are included in the licence, to ensure that there is ongoing oversight of the release.</p> <p>Volunteer plants from the GM Purple Tomato would be controlled by standard weed management practices the same as non-GM tomatoes.</p>