



Australian Macadamias Technical Guide

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Version	Date	Rationale
Version 1	01/03/2025	Issued

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Why choose Australian macadamia nuts



Versatile

With their distinct creamy flavour and versatile kernel sizes, macadamias are ideal for various applications, including macadamia oil, snacks, baked goods, chocolate and confectionary, dairy alternatives, savoury dishes and desserts. They offer versatility across sweet and savoury profiles and are suitable for inclusion in value-added foods.



Raw or roasted

Macadamias can be consumed raw or roasted, providing a variety of sensory, physicochemical and microbiological properties depending on the processing method.



Healthy

Macadamias are a nutrient-dense whole food, rich in monounsaturated fats, protein, fibre, vitamins, minerals, and antioxidants. Macadamias have particularly high levels of monounsaturated fats ('good fats') and contain Omega 3, 6 and 7 fatty acids.



Premium

Due to their unique flavour, texture, versatility and consumer perception, macadamias provide an opportunity to elevate the positioning of value-added products, enabling premiumisation.



Global leaders

Australia pioneered the macadamia processing industry, becoming the first producer to implement rigorous quality standards and testing protocols. With safety, freshness, and transparency at their core, Australian processors maintain stringent quality systems, meet high accreditation standards, and foster strong relationships with commercial partners globally, built on impeccable quality, food safety and service.



Multi-format

Macadamias are available in various kernel styles (from whole kernel to meal), grades and formats, offering solutions for a wide array of product applications.



Year-round availability

Harvested from March to September, and handled, processed and stored following world's best practice, Australian macadamias are available all year round.



Australian provenance

Native to Australia, macadamias are a unique part of the country's rich food heritage.



Sustainably produced

Macadamias are grown in commercial orchards on the east coast of Australia, following good agricultural practices and with a strong focus on compliance and sustainability.

More info

Australian macadamia industry info:
trade.australian-macadamias.org/

Australian bulk macadamia suppliers:
trade.australian-macadamias.org/suppliers/

Peak macadamia industry body

The Australian Macadamia Society (AMS) is the representative body for the macadamia industry in Australia.

Established in 1974, it is committed to advancing the Australian macadamia industry and promoting its exceptional products globally. The AMS represents macadamia growers, handlers and processors accounting for more than 85% of Australia's macadamia production. As well as growers, handlers and processors, the AMS's membership base includes representatives from across the supply chain including nurseries, consultants, researchers, marketers and commercial suppliers.

With its experienced team and a global network of partners, the AMS is regarded as one of Australia's strongest horticultural organisations, playing a pivotal role in fostering growth, innovation, collaboration and sustainability within the industry. It delivers a range of services including industry and market development, communication and engagement, and advocacy and representation where a united industry voice is stronger than any single business.



1. Macadamia Industry Overview



1.1 Australian macadamias

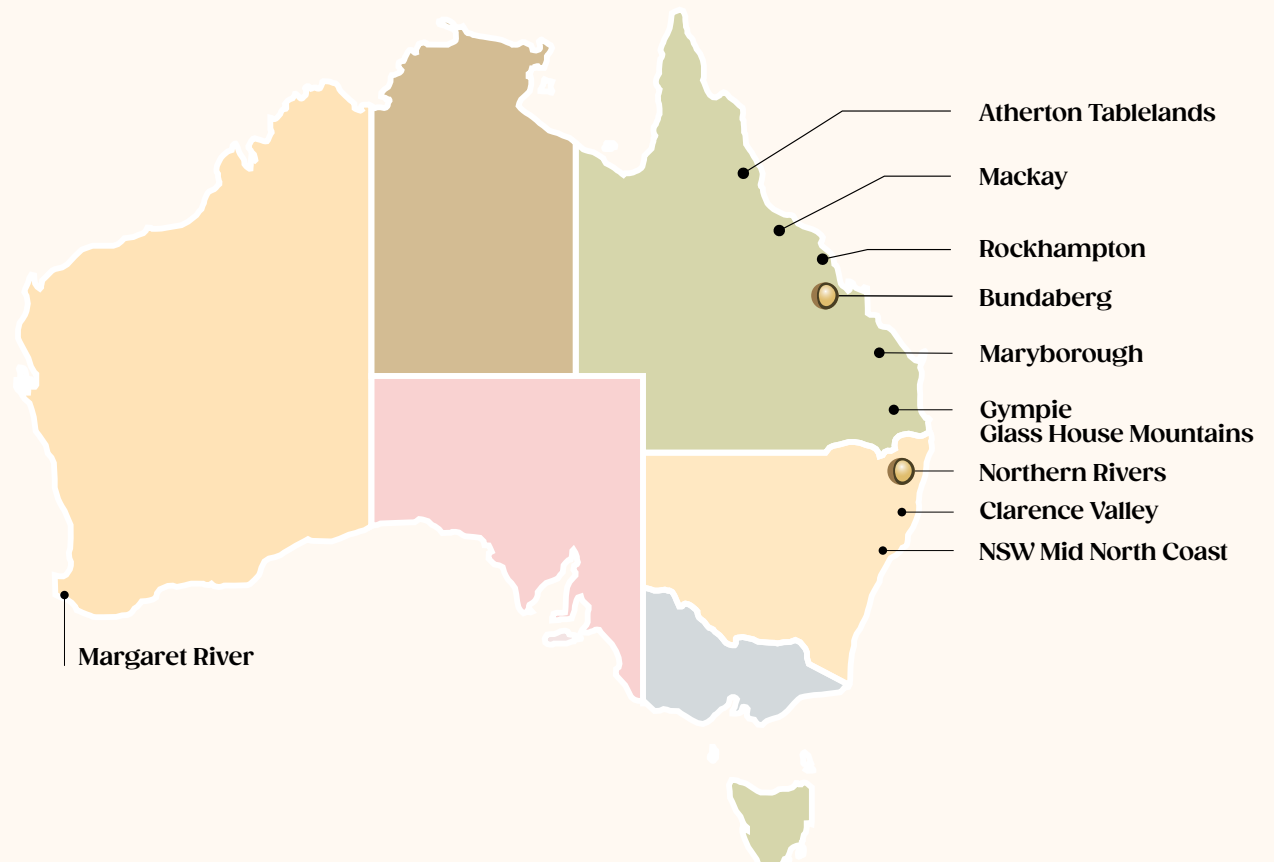
Macadamia nuts originate from the lush, subtropical rainforests of Australia.

They are native to the coastal areas of north-east New South Wales and south-east Queensland, with a smaller population found in central Queensland, where they flourish in their natural environment. The distinct climate of these regions, marked by mild temperatures and ample rainfall, creates the ideal conditions for macadamia trees. They thrive in temperatures between 20 and 25°C, which is essential for their optimal growth and nut production.

The genus *Macadamia* comprises four distinct species: Queensland Nut (*Macadamia integrifolia*), Rough-shelled Macadamia (*M. tetraphylla*), Gympie Nut (*M. ternifolia*) and Bulberin Nut (*M. janseniil*). Among these hybrid species, Queensland Nut and Rough-shelled Macadamia are cultivated commercially for macadamia nut production for human consumption.

Macadamia nuts have flourished in their native Australian habitat for millennia and have been commercially farmed for the past 60 years. Cultivating this unique health food requires both time and patience. Today, Australia has more than 800 growers across three states, producing around 55,000 tonnes per year, with 75% of the crop exported to more than 40 countries.

FIGURE 1.
Australia's macadamia growing regions



1.2 Macadamia seasons

Macadamia trees enter their flowering phase in early spring (August to October).

During this period, each tree bears sprays (racemes) of long, delicate, sweet-fragrant white or pink blossoms. Each spray consists of 100–300 flowers and yields 1–15 ‘nutlets’ that will eventually mature into nuts.

Macadamia nuts are formed in early summer, typically December. They grow encased in a hard, woody shell protected by a green-brown fibrous husk. Shell hardening occurs in early December followed by rapid oil accumulation from late December and January. By early autumn (typically March), the nuts are mature and appear as clusters of plump green nuts.

Between March and September, the mature nuts fall to the ground and are harvested regularly by mechanical harvesters. The fibrous outer husk is removed within 24 hours of harvest to minimise heat of respiration and facilitate drying. The nuts are then sent to processors for further processing. At the processing facility, the nuts are dried to approximately 1.5% moisture content to ensure the kernel shrinks away from the shell, preventing damage during automated cracking. A low moisture content also ensures the stability of the natural oils in macadamia kernel, preventing further oxidation of the oils and rancidity, as well as delivering the soft, crunchy texture that premium Australian macadamia kernel are renowned for.

FIGURE 2.
Macadamia nut life cycle



FIGURE 3.
Anatomy of a macadamia



1.3 Crop management

Australian macadamia growers follow world's best farming practices to deliver a premium nut whilst protecting their farming environment, and ensuring a sustainable future for the industry. Annually, the industry invests millions of dollars in research and development, seeking to continuously improve all aspects of macadamia production, nut quality and handling processes.

The Australian macadamia industry is a leader in sustainable orchard management practices, including the use of integrated pest management (IPM) and biological control on farm, to control pests and reduce pesticide use. Growers actively work to conserve and enhance natural resources.

The macadamia industry has participated in the Australian Government's National Residue Survey (NRS) for over 25 years. The NRS's annual program samples macadamias from Australian processing plants and tests for a range of chemical residues and environmental contaminants, verifying the good agricultural practices followed on farm and demonstrating the Australian macadamia industry's ability to meet strict quality assurance and market access requirements for domestic and international markets.

Australia's macadamia industry has achieved 100% compliance in the NRS, maintaining a perfect record every year since the Survey's inception in 1996. The annual NRS report, along with residue testing datasets, are available

at trade.australian-macadamias.org. Over time, the program has helped facilitate access to existing domestic and export markets and establish confidence to aid the development of emerging international markets.

The industry also supports local economies and engages in community activities. Through the Macadamia Conservation Trust, wild macadamias are protected, and a Species Recovery Plan recognised by the Australian Government has been developed.

1.4 Macadamia industry standard

As a world leading supplier of macadamias, the Australian macadamia industry adheres to stringent standards to ensure product quality, safety, and traceability. These standards help protect consumer confidence and uphold the reputation of processors and suppliers. For the industry, understanding and meeting these requirements is vital to competing successfully in the international market while maintaining exemplary quality standards.

TABLE 1.

Accepted industry standards for macadamia processors trading in the global market

Standard	Responsible party	Requirement
Certified HACCP system	Processors	Each processor must have a third-party certified and internationally recognised HACCP system in place. The system must be audited and certified by an accredited certification body. Buyers should request to see a copy of the certificate to ensure compliance and validity.
Food labelling	Suppliers and processors	Macadamia labelling is mandated by the regulatory body in which the product is processed and sold. All macadamia nuts sold must be labelled with the country of origin in which they were grown.
Kernel laboratory accreditation scheme (KLAS)	Accredited laboratories	KLAS was established to set clear, objective standards for macadamia kernel assessments. Laboratory compliance with the standard is crucial for consistency of assessment in determining financial returns and reporting to growers. All macadamia growers are encouraged to use AMS-accredited laboratories for these assessments.

2.

Macadamia Nut-In-Shell



Before producing macadamia kernels, processors implement specific handling and storage practices to ensure the quality of the final product.

Macadamia nut-in-shell (NIS) are stored in well-ventilated environments to minimise the risks of oxidation, rancidity, and mould growth, particularly given their high oil content. The nuts are dried to below 7.5% moisture within 14 days of intake. If kept in ambient conditions, they are processed within 90 days; otherwise, they are stored at temperatures below 15°C and relative humidity below 70% for up to 270 days.

It is recommended that raw kernels are stored at a maximum temperature of 12°C to preserve their quality. Additionally, all macadamias are subjected to specific physical specifications and must comply with Maximum Residue Limits for agricultural chemicals, ensuring that the kernels meet industry standards and consumer expectations.



3. Macadamia Kernel



Information provided for macadamia kernel is general in nature. Please refer to your macadamia supplier for details regarding their specific capabilities, processes and specifications.

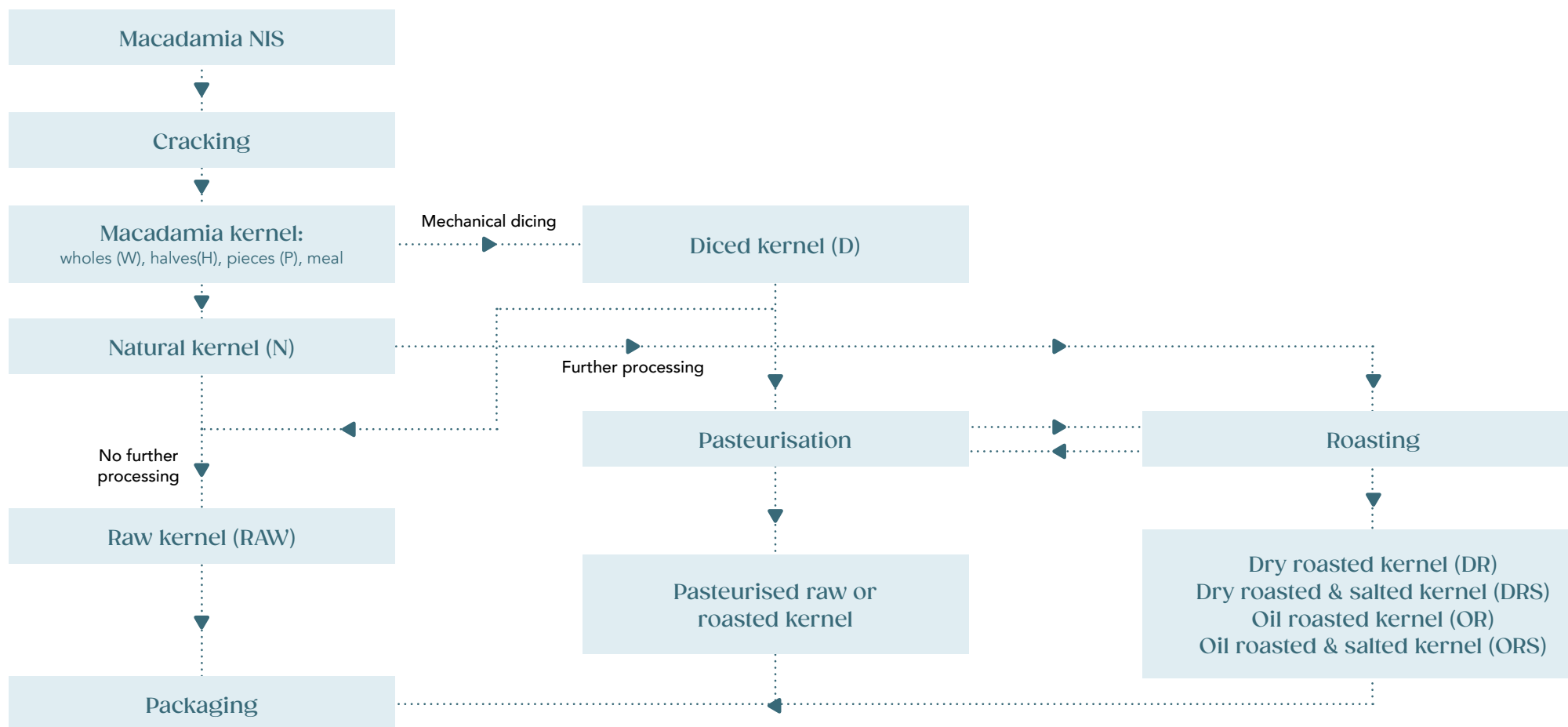
Most Australian macadamias are cracked and offered in kernel form. After cracking, the kernel is sorted into various sizes, known as styles. These styles can be achieved through natural means (cracking the nuts) or by mechanical dicing to precise dimensions. The kernel can either be further processed, for example by roasting or pasteurising, or retained in their original raw state prior to packing.

When using macadamias in the formulation of value-added end-products, careful consideration should be given to end product requirements, sensory attributes, potential interactions in the whole food matrix, quality parameters, further processing, shelf life, storage and packaging requirements. Consideration of such factors will provide the rationale for the macadamia style and pre-process requirements. The various macadamia pre-processing steps are detailed in Figure 4.



3.1 Kernel processing flowchart

FIGURE 4.
Macadamia kernel processing flowchart














Note: Terminology abbreviations are indicated in the brackets. Flavouring or coating can occur at different stages of the process depending on suppliers' equipment and techniques.

3.2 Style conventions

Macadamia kernel is categorised into styles numbered 0 to 8, with lower numbers indicating larger kernel sizes. Styles 0 through 4 consist of whole or half kernel, each with a specified size range and minimum amount of whole or half kernel. Styles 5 through 7 consist of kernel pieces, categorised by defined size ranges. Style 8 includes fine pieces or meal with sizes less than 4mm. Detailed information on the full range of styles is provided in Table 2. Customers may request kernel sizes based on the defined styles or collaborate with their suppliers to identify bespoke sizes to meet their specific needs.

TABLE 2.

Macadamia kernel styles

Style name	Kernel description	Size range in mm ¹	Images
Style 0	Min 95% whole kernel	>20mm	
Style 1	Min 90% whole kernel	17-20mm	
Style 1S	Min 90% whole kernel	14-18mm	
Style 2	Min 50% whole kernel	>13mm	
Style 3	Min 15% whole kernel	>13mm	
Style 4L	Min 80% halves	>13mm	
Style 4S	Min 50% halves	10-14mm	
Style 5	Pieces	8-12mm	
Style 6	Pieces	5-9mm	
Style 7	Pieces	3-6mm	
Style 8	Fine pieces or meal	<4mm	

1. Unless otherwise defined, the size ranges stated indicate that product will pass over a smaller round screen (with size expressed in mm diameter) and pass through a larger round screen (with size expressed in mm diameter). Alternative sizing methods may be used but must obtain equivalent sizing to that achieved by passing over a round screen. Size range in mm with a 10% tolerance for over or under-sized kernel.

3.3 Premium and Commercial grade kernel

The two primary macadamia kernel quality grades suitable for human consumption are **Premium Grade (PREM)** and **Commercial Grade (COM)**.

Premium Grade kernel is fully mature and free from significant defects, off odours and flavours. It represents the highest quality for direct consumption or high-value applications where the physical appearance of the kernel is paramount. While Premium Grade kernel is ideal for premium uses, it is also suitable for further processing.

Commercial Grade kernel exhibits minor visual defects, such as surface discolouration and immaturity, but is free from off odours and flavours. This grade is suitable for consumption in a variety of applications but is typically further processed through dicing or coating or may be used as an inclusion in a mixed food matrix.

Australia Macadamia Society KLAS Kernel Assessment Manual is used by suppliers and processors to specify the visual kernel standard across different quality grades. Selecting the appropriate kernel quality grade is crucial for optimising end-product quality and achieving value in the intended applications.

3.4 Natural and diced kernel and pieces

Kernel pieces and chips can be generated through the process of cracking the nut in shell (natural pieces) or through the dicing of kernel (diced pieces). Many processors have mechanical dicing capabilities to meet the growing demand for this format from the ingredient market and the stringent specifications that many products now demand. The particle size and shape will be dependent on the capability of the dicing machine used by your processor. The screening or sizing of the kernel pieces is important in providing product uniformity.

When selecting macadamia nut formats for use in value-added products, it is essential to consider the capabilities of production equipment, as well as market requirements and consumer expectations. Some applications will require the use of precise diced nuts, whereas others will benefit from the use of natural pieces.



3.5 Kernel processing

Macadamias can be consumed raw or roasted, with or without pasteurisation, providing a variety of sensory, physicochemical and microbiological properties depending on the processing method. The most suitable kernel option for your specific product development requirements should be discussed with your Australian macadamia supplier.

3.5.1. Raw kernel

Raw macadamia kernel refers to the edible inner part of the macadamia nut, which is dried and removed from its hard shell. The raw kernel retains the nut's natural flavour, soft texture, and pale cream to light white colour, delivering a mild, buttery taste with a hint of sweetness. Due to minimal exposure to heat, its original organoleptic properties, such as flavour, colour, texture and aroma, remain intact. The kernel's soft, slightly creamy mouthfeel makes it ideal for applications that emphasise delicate flavours and enhance creaminess.

3.5.2 Roasting

Roasting macadamias intensifies the buttery flavour and accentuates their unique crunch. There are two primary methods for roasting nuts: dry roasting and oil roasting. In the Australian macadamia industry, dry roasting is the preferred method for production, though there may be exceptions. Dry roasted nuts typically exhibit a creamy to dark brown colour, which may be customised to suit the end application and customer requirements. They should be free from excessively dark, burnt kernel and possess a

pleasant roasted flavour that is not overdone.

Macadamia nuts can either be purchased pre-roasted or roasted in-house prior to further processing. Before roasting a large quantity of macadamias, it is advisable to conduct a small test batch. The product should be evaluated, and the bed depth, time and temperature should be optimised to ensure the desired level of roast is achieved. For continuous nut roasters, such as a Proctor or Aeroglide, a suggested starting point is 125°C for approximately 11 minutes.

Considerations of consistent roasting:

- **Avoid mixing kernel sizes:** Use kernel of a consistent size to ensure even roasting.
- **Single layer roasting:** Arrange nuts in a single layer on the tray.
- **Optimise airflow and heat:** Adequate airflow and thermal uniformity for continuous ovens.
- **Regular agitation:** Agitate the tray regularly to promote even heat distribution.
- **Prompt removal:** Transfer nuts from the tray immediately after roasting to reduce continued cooking from residual heat. Consider use of a cooling mechanism such as a fan.

3.5.3 Pasteurisation

When macadamias are sold in a ready to eat format, it may be worth considering pasteurising the kernel. The primary purpose of pasteurisation is to address the risk of pathogen contamination on the kernel surface. In the macadamia industry, pasteurisation is commonly conducted using dry saturated steam under vacuum.

Pasteurisation should take place in a system that has been validated to provide a 5-log reduction in *Salmonella* using the Almond Board of California Guidelines for Process Validation Using *Enterococcus faecium* NRRL B-2354 method. It is essential that the processing parameters are optimised to achieve the required 5-log *Salmonella* reduction without compromising the organoleptic characteristics of the product.

Considerations of kernel pasteurisation:

- All kernel styles, from whole to meal, are suitable for pasteurisation depending on the equipment used
- Both raw and roasted kernel can be pasteurised and will retain their label descriptor as raw or roasted on the package after pasteurisation
- For roasted kernel, pasteurisation can be carried out either before or after roasting. Alternatively, equipment may have the capability to integrate both processes through adjustment of the steam and temperature settings.
- Macadamia kernel has a high oil content and is sensitive to heat and moisture. Excessive steam can cause surface cell rupture, leading to oil leakage and accelerated oxidation. The pasteurisation process is carefully controlled to preserve the product's organoleptic characteristics and maximise the shelf life of the raw material.

3.6 Kernel nutrition and health benefits

Macadamias are a unique wholefood, containing good fats, protein, fibre, vitamins, minerals and antioxidants. Grown naturally to nurture their unique taste and texture, macadamias are a delicious and nutrient-rich food choice.

Macadamias contain high levels of monounsaturated fats ('good fats', much like those found in avocados), and are high in Omega 3, 6 and 7 fatty acids. Additionally, macadamias are packed with essential vitamins, minerals, and dietary fibre, while being naturally low in sugar and carbohydrates. As a nutritional wholefood, macadamias are an excellent source of phytochemicals and antioxidants.

In line with key consumer trends, macadamias can enhance nutritionally dense food products and elevate offerings into premium and niche market segments.

TABLE 3.

Raw macadamia nutrition table

Raw, unsalted macadamias	Average quantity per 30g	Average quantity per 100g
Energy (kJ)	905	3018
Protein (g)	2.8	9.2
Fat Total (g)	22.2	74.0
Fat - Saturated (g)	3.0	10.0
Fat - Monounsaturated (g)	17.9	59.7
Fat - Polyunsaturated (g)	0.3	1.1
Fat - Omega 3 as ALA (mg)	60.0	200.0
Trans Fats (g) ¹	0.0	0.0
Carbohydrate - Total (g)	1.4	4.5
Carbohydrate - Sugars (g)	1.4	4.5
Dietary Fibre (g)	1.9	6.4

DATA Sources: Australian Food Composition Database (AFCD), except for trans fats¹ which is sourced from RMIT fatty acids database (Australia)



TABLE 4.

Vitamins and minerals in raw macadamias versus daily recommendations

Raw, unsalted macadamias	Average quantity per 30g serve	Average quantity per 100g	Percent of recommended daily intake per 30g serve
Sodium	0mg	1mg	0%
Potassium	123mg	410mg	3%
Magnesium	28mg	95mg	9%
Calcium	14mg	48mg	2%
Iron	0.54mg	1.80mg	4%
Zinc	0.40mg	1.20mg	3%
Vitamin B1 (Thiamine)	0.09mg	0.28mg	8%
Vitamin B2 (Riboflavin)	0.03mg	0.10mg	2%
Niacin	1.24mg	4.10mg	12%
Folate	3.30µg	11.00µg	2%
Vitamin B5 (Pantothenic acid)	0.12mg	0.40mg	4%
Vitamin B6	0.08mg	0.28mg	5%
Vitamin E	0.42mg	1.40mg	4%
Copper	0.11mg	0.36mg	12%
Manganese	1.53mg	5.10mg	31%
Selenium	3µg	10µg	4%
Arginine ²	0.40g	1.40g	N/A
Plant sterols ²	35mg	116mg	N/A

DATA Sources: AFCD, except for arginine and plant sterols² which are sourced from the US Department of Agriculture.

NOTES: %DI is Percentage Daily Intakes, based on an average adult diet of 8700kJ. Your daily intakes may be higher or lower depending upon your energy needs. RDI for vitamins are based on the FSANZ RDI: Recommended Dietary Intake (where available); OR Australian Nutrient Reference Values (NRVs) including Adequate Intake (AI) and Suggested Dietary Target (SDT).

4.

Macadamia Kernel Specification and Compliance



The Australian Macadamia Society has established minimum standards for microbiological, physical and chemical specifications tailored for the Australian industry. These standards may differ based on the limits set by the processor, destination country or client. It is the seller's responsibility to understand and comply with any agreed specifications.

All products are sampled and tested at the minimum rate of not less than 1.0kg for each production lot (or batch) of kernel. A 1.0kg test sample is collected using a minimum of 20 sub-samples, taken representatively throughout the production of the lot. The lot size for this purpose will not exceed 20 tonnes of kernel. However, if a validated pasteurisation process is used, the lot size may be increased to 30 tonnes. Samples represent each style produced, collected at the point of kernel packing.

All laboratories performing microbiological and chemical analyses are accredited by NATA, ISO 17025, or possess equivalent accreditation for food physicochemical and microbiological testing.

4.1 Microbiological standards

TABLE 5.

Australian microbiological testing requirements and limits

Organism	Max limits raw kernel	Max limits roasted kernel	Test method
<i>E-coli</i>	<3cfu/g ¹	<3cfu/g	(AS 5013.15-2006)
<i>Salmonella</i>	N.D./250g ²	N.D./250g	(AS 5013.10-2022)
Standard plate count	<30,000cfu/g	<3,000cfu/g	(AOCAC 990.12) or (AS 5013.1)
Yeasts and moulds	<20,000cfu/g	<2,000cfu/g	(AS1766.2.2-2009)

1 cfu/g: colony forming units per gram.

2 N.D./250g: not detected per 250 grams.

Note: With pasteurisation, lower microbiological limits can be achieved. Please consult with your suppliers for the specific microbiological limits applicable to pasteurised kernel.

4.2 Chemical standards

TABLE 6.

FSANZ* chemical testing requirements and limits (at time of packing)

Organism	Max limits raw kernel	Test method
Total aflatoxin	<0.015mg/kg	HPLC/LCMS
Free fatty acids	0.8%	(AOCS Ca-5a-40)
Peroxide value	One year shelf life: between 2 and 3meq/kg; Two year shelf life: ≤2meq/kg ¹	(AOCS Cd-8b-90)

¹ meq/kg: milliequivalents of free iodine per kilogram of fat

* Food Standards Australia New Zealand

4.3 Physical standards

TABLE 7.

Physical kernel specifications

Characteristic	Premium grade
Kernel moisture content	Not to exceed 1.8%
Appearance and taste	<ul style="list-style-type: none"> • White/cream in colour or as specified for roasted product • Free from excessive dust or oil • Crunchy texture (excluding meal) with typical macadamia flavour • Free from off odours and flavours
Foreign matter ¹	Target nil
Loose shell ²	≤1 piece per 100kg
Impacted shell ³	≤1% of kernel by weight
Unsound kernel (Reject plus Commercial Grade kernel) ⁴	No more than a combined total of 3% of Unsound kernel by weight of which Reject kernel should not exceed 2% by weight
Visible mould	Target nil
Wholes, halves, pieces count	Should meet specification or customer requirements

¹ Foreign matter includes any product that is not kernel and/or shell.

² Loose shell is defined as pieces of shell that cannot pass through a 3mm round hole.

³ Impacted shell is defined as shell that is embedded in the kernel and cannot pass through a 2mm round hole

⁴ The definitions for Reject and Commercial Grade kernel can be found in the Australian Macadamia Society KLAS Kernel Assessment Manual.

4.4 Shelf life

TABLE 8.

Shelf-life specifications for raw kernel in packaging up to 25kg, when stored at $\leq 12^{\circ}\text{C}$

Best before	Peroxide value at packing	Barrier properties of packaging ¹	Residual oxygen
24 months from date of packing	$\leq 2\text{meq/kg}$	Oxygen - $<0.10\text{cc/m}^2/24\text{h}$ Water - $<0.25\text{g/m}^2/24\text{h}$	$\leq 2\%$
12 months from date of packing	Between 2 and 3meq/kg	Oxygen - $<0.10\text{cc/m}^2/24\text{h}$ Water - $<0.25\text{g/m}^2/24\text{h}$	$\leq 2\%$

¹ (at 25°C , 75% RH, 1atm)

4.5 Retention samples

A minimum of 400g of macadamias from each batch are retained for microbiological, chemical and physical analysis. These samples are stored under the recommended conditions for the shelf life of the product, in packaging that maintains the product's integrity for the intended testing purposes.

4.6 Traceability

All macadamia products have end-to-end traceability from farm to processor, and on to final specified end customer. The ability to trace back to orchard, and forward to end customer ensures any production or supply chain issues can be quickly identified and effectively managed to the benefit of all parties.

For macadamias that are intended to be used as raw materials in value-added end-products, the following information will be provided either on the bulk packaging or in the specifications:

- Packer or seller's name, address and contact details
- Country of origin
- Product code
- Lot code or unique code
- Net weight
- Shelf life (either by best before date or shelf-life statement)
- Recommended storage conditions

4.7 Specifications

Processors should provide a product specification sheet for each product. This sheet should include the following information:

- Product code
- Supplier information
- Kernel grade/style
- Country of origin
- Allergen declaration
- Gene technology statement
- Nutrition information
- Product size details
- Description of acceptable taste and aroma
- Maximum acceptable moisture content
- Maximum levels of defective kernel, impacted shell and foreign material
- Maximum microbiological levels for *Salmonella*, *E-coli*, Standard Plate Count, Yeasts and Moulds
- Maximum levels for Aflatoxin, Peroxide Value and Free Fatty Acid
- Description of the pack date, shelf life and/or best before date
- Recommended storage conditions

4.8 Certificate of analysis

Each shipment must be accompanied by a Certificate of Analysis, which should include the following information for each batch of kernel in the shipment:

- Details of the batch numbers contained in the shipment
- The level of *Salmonella* (not detected/250g) and *E. coli* (<3cfu/g)
- The levels for aflatoxin for each batch
- The peroxide value and free fatty acid values for each batch
- The moisture content of each batch



5.

Macadamia Kernel Storage and Handling



The elevated fat content in macadamias necessitates specific storage and handling conditions. It is recommended that macadamia kernel be stored at temperatures below 12°C in appropriate packaging. When packed and stored with adequate moisture and oxygen control, macadamia kernel can achieve an extended shelf life.

5.1 Bulk packaging

Bulk packaging specifications for kernel

Effective control of moisture and oxygen levels during packaging is essential to maintain product quality throughout shelf life. To maintain the maximum shelf life of 24 months, product is packed under controlled atmosphere using Modified Atmosphere Packaging (MAP), with high barrier foil films.

Recommended packaging structure:

- Liner composition: 12µm PET / 9µm Foil / 120µm LLDPE
- Flushing and sealing: Nitrogen or carbon dioxide flushed and vacuum-sealed
- Residual oxygen level: Less than 2%
- Barrier transmission rate at 25°C, 75% RH, 1atm: Oxygen barrier <0.10cc/m²/24h; water barrier <0.25g/m²/24h

An outer carton is used to store MAP-packed foil bags, providing a secondary layer of protection against dust and other environmental contaminants.

Once macadamia kernel is exposed to ambient air it can rapidly accumulate moisture due to its low moisture content. This can lead to loss of the kernel's crunchy texture and increase the risk of oxidation of their natural oils, which can reduce eating quality and shelf life. If a carton is opened and only partially used, it is recommended that the bag is resealed, or the remaining product is placed into a sealed plastic container and stored below 12°C.

5.2 Considerations for retail packaging

Retail packaging is typically not vacuum-sealed; therefore, the barrier properties of the packaging materials play a critical role in determining the shelf life of the product.

Various types of retail packaging are available, each offering different levels of protection. The effectiveness of a packaging material in blocking oxygen and moisture generally correlates with a longer shelf life for the product. For optimal shelf life, it is recommended to use packaging materials with high barrier properties, such as high barrier flexible films, or hermetically sealed metal cans or glass jars in conjunction with modified atmospheric conditions (low oxygen). It is the retail packer's responsibility to determine the shelf life of their product, considering the kernel treatment and the packaging employed.

5.3 Considerations for retail loose nuts/ non packaged

When selling macadamia kernel through bulk containers in store, it is more challenging to maintain the product's freshness and crunch as there is no barrier to oxygen or moisture. However, by adopting some simple practices, the quality attributes of the products can be maintained:

- Ensure the hopper has a lid that closes once the consumer/retail assistant has taken the required volume of macadamias.
- Keep only a small amount of product in the hopper at any given time to ensure it will be turned over quickly, ideally every 2-3 days.
- When refilling the hopper, remove all remaining kernel first and set aside, then remove and discard any dust. Place the fresh kernel on the bottom of the clean hopper before replacing the older product on top.

6.

Considerations for Specific End-Use Applications



Macadamia kernel can be blended with other ingredients to produce mixed nuts and cereals, chocolate-coated macadamias, bakery products, ice-cream and snacks. It is important to consider the moisture content of each ingredient, along with the whole food matrix, the desired quality attributes, sensory properties, further processing, packaging and shelf life of the end-product. Specific kernel formats may be required, such as those which have been pre-processed via pasteurisation, roasting, dicing or coating. Additionally, macadamias can be processed into milk and used as a non-dairy alternative in products such as yoghurt, cream and ice cream. Macadamia oil can be extracted from the nuts for further use and sale. Macadamia oil provides a mild, buttery and creamy taste and is a good source of healthy monounsaturated fats.

6.1 Mixed nuts and cereals

Macadamia kernel, with a moisture content of up to 1.8%, is relatively low in moisture compared to other ingredients typically used in mixed nuts and cereals. When blending raw materials of varying moisture levels, the moisture content of the packaged product is likely to equilibrate over time. If macadamias are blended with higher moisture content materials, the moisture content of the macadamias may gradually increase over time, potentially impacting their eating quality and shelf life. Furthermore, the overall shelf life of the mixed food must be validated and is typically dictated by the ingredient with the shortest shelf life in the formulation.

6.2 Chocolate coated macadamias

It is common to roast macadamia kernel before coating in the chocolate application, as roasting enhances the flavour and complements the chocolate. Lightly roasted nuts retain more of their natural nut flavour, while darker roasting imparts a stronger nutty taste.

Applying a layer of oil to the kernel prior to coating creates a protective barrier around the kernel, preventing moisture transfer from the chocolate. This barrier also minimises the migration of natural oils, which can lead to fat bloom in the chocolate.

Care should be taken to completely cover the nut as exposed kernel facilitates fat bloom and reduces saleable shelf life.

For optimal quality, chocolate coated macadamias are best stored in a dry and cool storeroom between 18 and 25°C and at a relative humidity of less than 60%. Storing within this temperature range prevents the chocolate from melting or softening at higher temperatures. It also avoids the formation of fat bloom, which typically occurs below 15°C and adversely affects the appearance of the final product.



6.3 Ice-cream

When incorporated into ice-cream, macadamia kernel is often coated to inhibit moisture absorption. For instance, a coating of honey can help slow moisture uptake in the kernel. Alternatively, applying a layer of oil can create a protective layer around the kernel, further reducing their ability to absorb moisture.

6.4 Savoury or sweet snacks

Enhancing the flavour of macadamias can be achieved by coating with salt, a savoury herb and spice mix, or sweet liquids such as honey or maple syrup. These complementary flavours can highlight and accentuate the unique characteristics of macadamias. Coating can be applied either before or after roasting, depending on equipment availability, process capability and the specific product profile.

Coating before roasting allows deeper flavour absorption and caramelisation.

Consideration should be given to the effect of heat on the flavour and colour of the coating materials. This method also presents risks of burning, excessive browning and retention of moisture, which could affect the quality of the end product. **Coating after roasting** offers better control over flavour intensity, avoids burning and helps maintain the crunchiness. However, care should be exercised to ensure the even dispersion and adhesion of seasoning. Therefore, choosing the appropriate coating and roasting method is essential for achieving the desired product characteristics.

Considerations for coating before roasting:

- **Minimise the risk of burning:** Select coating ingredients that can withstand high temperatures or adjust the roasting temperature and time to optimise the flavour and colour of the product. If using delicate ingredients like sugar or herbs, ensure they are applied in thin, even layers.
- **Prevent moisture retention:** Use a coating that does not trap excess moisture. Alternatively, roast at a lower temperature for a longer time and closely monitor the moisture level of the nuts to ensure the desired texture and moisture content is achieved, without burning.

- **Maintain temperature control:** Regularly check and calibrate roasting ovens to ensure even heat distribution. Ensure adequate heat circulation and airflow in the roasting chamber to avoid hot spots, which can cause uneven roasting.

Considerations when coating flavours after roasting:

- **Salt or dry powders:** To ensure even adherence, sprinkle salt or dry powders on the nuts while they are still hot, following roasting.
- **Oil for better adherence:** Lightly spray the nuts with oil before applying any seasonings. This ensures the flavours will adhere more effectively.
- **Liquid flavours:** Combine the liquid flavourings with oil and heat the mixture. Apply the flavoured oil to the hot nuts for even distribution.



6.5 Milk

Macadamia milk is typically made from macadamia paste, which can be produced from raw, pasteurised or roasted kernel, depending upon the flavour profile required. The nuts are finely ground into a smooth, free-flowing paste. This paste is then blended with water, starch, vegetable gums, protein, and other functional ingredients to create a nutritious and appealing milk product, with a typical nut inclusion rate of 2.5–3.5% in the milk. For large-scale production, and with the appropriate equipment, macadamia milk can also be made by blending soaked macadamia nuts with water.

Known for its creamy texture and buttery flavour, macadamia milk is emerging as a popular dairy alternative. It offers healthy monounsaturated fats, vitamins and minerals, making it a nutritious substitute for dairy milk. Additionally, macadamia milk is suitable for vegan and lactose free consumers. It is also free from common allergens such as soy, milk and gluten, making it a versatile choice for various consumer needs.

Considerations of macadamia milk applications:

- **Milk drink:** Its unique creamy, buttery and nutty flavour makes macadamia milk an excellent choice for drinking on its own, or adding to cereal, tea, coffee, smoothies and homemade ice cream.
- **Sauces and soups:** Use it as a creamy base for sauces and soups.
- **Baking:** Replace water or dairy milk with macadamia milk in baking to enhance creaminess and impart a distinctive buttery and nutty taste.
- **Barista milk:** Macadamia milk stabilised with vegetable gums, creates the ideal texture for preparing coffee and smoothies. An acidity regulation ingredient should be added to combat 'splitting' of milk due to coffee's acidity.

6.6 Oil

Macadamias are recognised for their elevated content of monounsaturated fats, commonly known as healthy fats. This high concentration of monounsaturated fats enhances the oxidative stability of macadamia oil, rendering it more resistant to degradation compared to many other plant oils. Consequently, macadamia oil exhibits a notable shelf life of up to five years when stored in dark glass bottles in a cool, dark environment. Moreover, its high smoke point of 210°C renders it suitable for high-temperature cooking. In addition to these functional attributes, macadamia oil is distinguished by its mild, buttery and creamy flavour, which enhances a diverse range of culinary applications.

Considerations of macadamia oil application:

- **Salad dressings:** Its mild, buttery flavour makes macadamia oil an excellent base for salad dressings and a suitable alternative to olive oil.
- **Marinades:** Macadamia oil can be used as a substitute for any oil in marinades to add a unique richness.
- **Baking:** Replace butter with macadamia oil in baking recipes, using a 1:1 ratio for a buttery taste and texture.
- **Stir frying:** Macadamia oil is an excellent choice for stir frying, imparting a subtle buttery aroma and flavour to your dishes.
- **Pan and deep frying:** Refined macadamia oil has a high smoke point, making it ideal for both pan and deep frying. This stability ensures a crisp, golden finish without the risk of burning.



7.

Matrix of Recommended Applications for Macadamia Kernel and Paste



Application	Style 0	Style 1	Style 1S	Style 2	Style 3	Style 4L	Style 4S	Style 5	Style 6	Style 7	Style 8	Paste
	Whole				Halves			Pieces			Meal	Paste
Snack	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-
Mixed nuts	-	✓	✓	✓	✓	✓	✓	-	-	-	-	-
Chocolate and confectionary	-	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓
Trail mix	-	-	-	-	✓	✓	✓	-	-	-	-	-
Baking	-	-	-	-	-	✓	✓	✓	✓	✓	✓	✓
Ice-cream/dessert	-	-	-	-	-	-	-	✓	✓	✓	-	✓
Bread	-	-	-	-	-	-	-	✓	✓	✓	✓	✓
Bars/bliss balls	-	-	-	-	-	-	-	✓	✓	✓	-	✓
Muesli	-	-	-	-	-	-	-	✓	✓	✓	-	-
Topping	-	-	-	-	-	-	-	✓	✓	✓	-	✓
Sauce/dip	-	-	-	-	-	-	-	-	✓	✓	✓	✓
Savoury sprinkles	-	-	-	-	-	-	-	-	✓	✓	✓	-
Beverages	-	-	-	-	-	-	-	-	✓	✓	✓	✓
Milk/dairy alternatives	-	-	-	-	-	-	-	-	✓	✓	✓	✓
Praline/nut paste	-	-	-	-	-	-	-	-	-	✓	✓	✓

Note: This matrix serves as a guide only. Please contact your supplier for specific requirements.

8.

Australian Bulk Macadamia Suppliers





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This project has been funded by Hort Innovation using the macadamia marketing levy. For more information on the fund and strategic levy investment visit horticulture.com.au