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## Glossary

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Maturity and its determination is one of the most important factors governing the quality of macadamias at harvest. Fallen macadamias should ideally be collected at least once per week to preserve optimum quality. For stilleight, the ideal length of the harvest window is dependent on seasonal conditions, but this seldom exceeds two weeks for most varieties. The skilled grower will do regular maturity tests to determine peak oil content and harvest at the first opportunity. The present trend to initiate abscission is by using ethephon (2-chloroethylphosphonic acid) or manually harvest by hand. The use of ethephon has the benefits of optimizing the harvest period at maturity as well as reducing labour requirements and controlling theft.

In Australia the CSIRO (Council for Scientific and Industrial Research Organisation) established that 'commercial' maturity (>70% oil) occurs about 4 weeks before significant abscission. Richard Mason established a practical method for testing and predicting for maturity (1983) as well as providing an indicator of quality by establishing the percentage of 'first grade' kernels. The principle employed is to dry the sample macadamia kernels to 1.5% moisture content and then float them in clean water (Specific gravity (SG) = 1.0). Macadamia kernels with an oil percentage of 70% or more will have a SG < 1.0 and will therefore float. A sample of kernels where 95% or more are floating is considered mature. This method can also be used predictively to establish an ideal harvest date by doing the same test monthly from December and plotting the increasing percentage of floating kernels (see Chapter 2.3.6).

1.8.2 Growing Risks

The macadamia is a high-energy food source and at risk from many opportunistic feeders. Any agent that can break the integrity of the kernel will cause oil spillage and initiate the process of rancidity. Insect damage is a grower management issue that requires both cultural and chemical control throughout the growing season prior to harvest. Post-harvest sorting of de-husked NIS is necessary to remove obvious damage such as that caused by nut borers or moth larvae.

Fungal spores germinate easily in the presence of free water and the hyphae penetrate the kernel easily. The damage caused by rampant fungal growth is easily sorted visually, but the initial invasion is microscopic and invisible. The early damage caused still, however, provides a foothold for the beginning of rancidity.

Kernel integrity that has become compromised by the various species of stinkbug is virtually impossible to visually sort at farm level because the stylet entry point is microscopic. Kernel that has been damaged by stinkbug can only be removed visually after cracking on the processors' sorting conveyor. Removed kernels - damaged cells physically removed by human intervention - are candidates for early rancidity.

The importance of the prevention of insect damage and the timely collection of macadamias from a wet orchard floor cannot be overstated. The South African industry loses from visually sorted insect and fungal damage amounts to about 82% of the total rejected kernel, or about 20 million Rand (US $2 million 2018). The loss of shelf-life as a result of damaged kernel that passes inspection at the processor is not known, but I would estimate that probably more than 50% of macadamia kernels processed in South Africa have a shelf-life of less than 6 months.

1.8.3 Handling Risks

Bruising results in cell damage and split oil. Bruised cells may occur deep within the kernel or on its surface depending on the source of the impact or compression. Bruising usually results from indiscriminate handling, dropping, rattling or compression at the debucker especially at farm level when the kernel moisture content exceeds 12%. Deep bruising cannot be recognized on the processors' sorting conveyor, but it is a shelf-life issue since the split oil will eventually diffuse to the kernel surface. Apart from the rancidity concerns bruised kernels will also exhibit unsightly blemishes during roasting that have little or nothing to do with the cultivar type or growing conditions.

Shoulder damage to kernels usually occurs within the shell when the nut-in-shell (NIS) have a moisture content of less than 8% and are roughly handled. Sharp impact and rough handling vibrations all contribute to damage to the kernel epidermis, the formation of kernel meal (dust) and/or shoulder chipping. Macadamias that have been dried too fast will form stress fractures on the surface of the kernels and are more susceptible to shoulder damage. Any damage to the kernel epidermis or to its shoulders will expose the split oil to oxygen and the initiation of rancidity.

Dried mature kernel floating in water

Kernels with exposed epidermis

Macadamia bruised during rough handling, white dry in shell

High oil content, seen under a microscope

Easy Let-downs. Methods to prevent mechanical damage to NIS.
2.2 MACADAMIA NUT CARE: A post-harvest overview

2.2.1 The Purpose of the Seed

The macadamia nut-in-husk (NIH) is the reproductive seed of the parent plant with its unique implanted genetic instruction, biological features and mechanical structure to perpetuate its species. The parent plant, when subjected to ideal conditions, produces a great number of these seeds in order to take full advantage of the prevailing happy circumstances.

The skilled manipulation of environmental conditions such as canopy management (light for photosynthesis), water availability (irrigation), nutrient provision (soil and leaf analysis for fertilizer requirement), weed control (herbicide application) and insect management (pesticides and IPM) all provide for optimum production of macadamias.

These seeds are not however intended for reproduction and great care must be taken to avoid subjecting them to the natural conditions that will cause germination or otherwise reduce their aesthetic and/or edible quality.

2.2.2 Production Problems

The general phenoegen pattern of the macadamia species that provide the 50 plus plant varieties (hybrids and cultivars) do not vary much, but individual cultivar characteristics are significantly different due to cultural practices, climate, altitude and latitude. The ideal macadamia tree should also produce consistently in spite of temperature extremes.

Plant breeders continue to develop new cultivars in search for a disease and insect resistant macadamia tree that also produces a high yield of quality nuts with secure, thin shells. This ideal utopian tree has not yet been bred, but the present multitude of accepted cultivars has provided for macadamias that have a great number of physiological differences between their different seeds. These differences include:

1. Seed size
2. Allocation potential
3. Husk thickness
4. Shell thickness
5. Shell porosity (fibre density)
6. Cotyledon binding mechanism (strength)
7. Kernel size
8. Kernel moisture content
9. Kernel cell wall thickness
10. Oil content
11. Sugar content
12. Roasting potential
13. Moisture content
14. Potential for water absorption
15. Potential for discoloration
16. Moisture diffusion (between cells)
17. Shrinkage rate and ratio
18. Enzymatic potential
19. Maturity at harvest

These differences may be exacerbated negatively by the:
1. Time taken to bring in the harvest,
2. The climatic conditions that prevail at harvest and the
3. Methods employed to physically effect the harvest.

The search for the utopian macadamia tree drives researchers to investigate many avenues that attempt to establish the genetic predisposition of defects such as browning, discoloration and brown centering. However the more important causes are combinations of thermodynamic, psychrometric and mechanical effects brought about by poor handling by untrained operators or by the use of poorly designed equipment.

Loss of flavour and texture may be caused or exaggerated by the following undesirable or a combination of undesirable elements:

1. Over-maturity (late harvest and/or abscission of sticks-tights)
2. Immaturity (mechanical - wind & hail, chemical or insect intervention causing premature abscission)
3. Enzymatic discoloration of kernel (long available reaction time)
4. Distal end discoloration and onion ring (time delay at harvest and/or moisture absorption post maturity)
5. Loss of crispness (excessive respiration time / high moisture content create ideal conditions for rapid enzymatic activity)
6. Mould (susceptibility in damp conditions - rain and wet storage)
7. Heat damage (exposure to sun and other heat energy sources)
8. Bruising (due to hail, de-husking, rough handling)
9. Insect damage (susceptibility of selected cultivar and/or poor management)
Macadamia Susceptibility to Rancidity

A 1st grade mature macadamia kernel is well endowed with about 70% - 75% fats (oil) with a high smoke point (210°C). The macadamia has the highest monounsaturated oil content of any nut (about 85% of total fat), but is also blessed with very high natural antioxidant chemicals (especially tocopherol) that add to human nutritional advantage. Any mechanical action on the kernel that causes a minute spillage of this oil, even while still in its hard shell, whether from mishandled or improper storage, insect or rough handling that causes bruising or chipping that damage cells, will result in the exposure of the oil to atmospheric oxygen and moisture – culminating in the initiation of rancidity.

![Peroxide Limit Smell/FFA 0.1%](image)

Figure 2.9: Rancidity and shelf-life
The risk of rancidity begins on-farm, but can be initiated at any stage of processing and especially during cracking. The need for an educated partnership between grower and processor is paramount in producing the consumers with quality macadamia.

The natural antioxidant that is released and exposed by the bruised cells at the site of the injury quickly limits the scale of oxygen absorption – but this also reduces the nutritional antioxidant benefit of the nut to humans.

Elevated temperatures exacerbate the situation and cause an increase in oil seepage due to its lower viscosity. The exposure of the oil then, in turn, results in rapid oxidation and increased enzymatic activity that promotes quality loss in other components of the macadamia kernel. The presence of trace metals – especially iron and copper – accelerates rancidity and this is of particular importance when kernels are roasted in oil.

The initiation and progress of rancidity is also promoted by bacterial action, high water activity (Aw) and the presence of light – especially ultra violet ‘UV’. (Special care must be taken with the Beaumont cultivar as its kernels have higher levels of linoleic acid that make its oil more susceptible to oxidation (Ingrid Weintert '93 SAMAC yearbook).

But, the most prominent agent for the advancement of rancidity, is the passage of time.

The key point to note is that oxidation begins immediately after any amount of oil becomes exposed to the atmosphere and once the process begins it is irreversible. Management measures such as removing the exposure to oxygen and lowering the temperature will arrest the progress temporarily, but oxidation will continue to develop at a rate that ambient conditions allow.

The best way to improve the shelf-life of damaged macadamias is to reduce the process time from tree to packaging. Some value adding processes will arrest oxidation – such as the timely coating of the kernels in chocolate or nougat – but this will only account for small volumes of macadamias. Other value adding processes such as roasting have a limited effect on improving characteristics of shelf life that is lost by enzymatic activity such as texture (crunch). The only other viable alternative is to ensure that consumption occurs before poor palatability is detected.

---

Macadamia Compared To Other Nuts

Table 2.2 shows the mean composition of the proximate constituents of many of the common nuts. A feature of nuts is their high content of oil and protein. Macadamias have the highest total oil while peanuts contain the highest levels of protein.

<table>
<thead>
<tr>
<th>Nut</th>
<th>Macadamia</th>
<th>Peanut</th>
<th>Walnut</th>
<th>Brazil</th>
<th>Almond</th>
<th>Pistachio</th>
<th>Cashew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (g)</td>
<td>75</td>
<td>71</td>
<td>59</td>
<td>64</td>
<td>54</td>
<td>54</td>
<td>46</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>8</td>
<td>9</td>
<td>21</td>
<td>15</td>
<td>14</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>16</td>
<td>10</td>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>Omega 7 (g)</td>
<td>12.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.23</td>
<td>0.24</td>
<td>0.46</td>
</tr>
<tr>
<td>Fibre (g)</td>
<td>2.5</td>
<td>2.3</td>
<td>1.7</td>
<td>2.1</td>
<td>3.1</td>
<td>2.6</td>
<td>1.9</td>
</tr>
<tr>
<td>Energy (Cal)</td>
<td>691</td>
<td>687</td>
<td>621</td>
<td>651</td>
<td>654</td>
<td>598</td>
<td>564</td>
</tr>
<tr>
<td>Safe Moisture Content (%)</td>
<td>3</td>
<td>3.4</td>
<td>3.1</td>
<td>3.5</td>
<td>4.6</td>
<td>4.7</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Nut Storage Risk Index

Macadamia kernels are, like many of the other commercial nuts indicated in the table above, very fragile and can easily be damaged during poor handling and unsafe storage parameters. The nut storage risk index value - Table 2.5 below – provides an indication of the relative risk of different nuts based on their oil content and safe moisture content.

The higher the index value the more care must be taken with storage parameters.

<table>
<thead>
<tr>
<th>NUT</th>
<th>Macadamia</th>
<th>Peanut</th>
<th>Walnut</th>
<th>Brazil</th>
<th>Almond</th>
<th>Pistachio</th>
<th>Cashew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat %</td>
<td>7%</td>
<td>7%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Safe mc (%)</td>
<td>3</td>
<td>3.4</td>
<td>3.1</td>
<td>3.5</td>
<td>4.6</td>
<td>4.7</td>
<td>5.3</td>
</tr>
<tr>
<td>Index</td>
<td>25.0</td>
<td>20.9</td>
<td>18.0</td>
<td>16.3</td>
<td>14.4</td>
<td>11.5</td>
<td>10.2</td>
</tr>
</tbody>
</table>

From Table 2.5 macadamia cannot be stored in the same conditions as, for example, almonds. Macadamias have the highest risk index of all nuts and need more careful management than the other nuts to preserve shelf-life. Damaged macadamia kernels are especially subject to shelf-life loss. If the damage is light then the naturally occurring antioxidants are able to control the formation of free radicals and, together with management tools such as low temperature storage in gas flushed packaging, provide for a longer protection. Whole kernels that are rapidly packaged after cracking and stored in ideal conditions will have a long shelf-life potential.

The ideal storage condition should be similar to that which would be applied to a tub of butter – conditions that will ensure a low rancidity potential, best quality, best price, long shelf-life and an accurate sell-by-date.
3.10 UNDERSTANDING MACADAMIA MOISTURE CONTENT

3.10.1 Moisture Content - A Contentious Issue

It is clear to any grower delivering NIS to the processor that small percentage inaccuracies in measurement and/or calculation can lead to large variances in pay-out values. The incorrect interpretation of moisture content NIS or kernel has created a great deal of confusion in the industry and is now becoming a contentious issue. The global macadamia industry needs to reach a consensus on a fair, transparent, accurate and simple common standard for measuring moisture content on which to base payment calculations, which is understood and accepted by both processors and growers.

3.10.2 Why is there a Need to Measure Macadamia Moisture Content?

Moisture promotes the deterioration of biological chemistry by bringing its reactants into proximity with each other providing a respiration energy pathway for metabolism. The reactions that take place are faster in warm conditions and are accelerated with an increase in temperature. The degree and rate of deterioration of raw macadamia, while still in the husk or as nut-in-shell, is therefore, dependent on the moisture content in combination with storage temperature and duration.

Raw macadamia kernel is very sensitive to hydrolytic rancidity that results from prolonged exposure to moisture and it is essential that a grower/operator has a sound understanding of where the moisture is found in the macadamia and the safe mc limits and methods that must be applied to preserve quality.

3.10.3 Macadamia Nut-in-Husk (NIH)

While on the tree, the husk has approximately 32% of the macadamia mass, of which 60% is water to aid germination. It is essential to remove this reservoir of water by de-husking macadamias immediately after harvest to prevent the potential vital heat of respiration causing severe and rapid deterioration of the kernel. The storage of nut-in-husk, especially in closed containers, is a self-generating composting process that can result in exponential runaway temperature increases beyond 50°C within a few days. The safe maximum temperature difference between the inside (kernel) and the outside (NIH) during dehydration is 7°C.

3.10.4 Macadamia Nut-in-Shell (NIS)

The vital metabolic heat produced by the respiration of unventilated wet nut-in-shell is not as high as that resulting from storage of nut-in-husk, but it is still sufficient to generate high temperatures that can, within a few days and in combination with high humidity, severely reduce the shelf-life of the macadamia kernel.

The quality of the freshly harvested macadamia - that is its potential shelf-life - is dependent on the rapid removal of both the respiration heat and the moisture that is its source. The rate of moisture removal, must however, occur within controlled parameters (curing) - temperature, air speed, time - if the good harvest quality of the weakest macadamia in the batch, is to be preserved.

3.10.5 Deterioration of Kernel

Macadamias are typically sold as NIS at 2.0% kernel moisture content (6.5% - 6.0% NIS mc) or as kernel at 1.5% mc (3.5% NIS mc). The moisture content at this level will retard metabolism substantially, but will not eliminate it. Natural enzymes will continue to reduce the shelf-life of the kernel especially at elevated temperatures. The molecular components of the kernel will expand with temperature again bringing the enzymatic reactants into contact with each other. Every 10°C rise in kernel temperature will double the rate of metabolic activity (deterioration) that shortens shelf-life. Therefore, the combination of low temperature in addition to moisture removal is the most salient method of preserving macadamias.

3.10.6 Distribution of Moisture in NIH at Abscession

Moisture in the NIH is stored in three reservoirs viz; 1. Husk,
2. shell, and

Figure 3.1: Approximate NIH mass distribution

3.10.7 Understanding Macadamia Industry Moisture Content Terminology

The macadamia industry refers to two moisture parameters - NIS% mc and kernel mc%.

1. NIS mc%: This value is intended to refer to the combined moisture in the kernel and the shell. These two structures are very different materials and their abilities to hold water are vastly different. A 10% NIS mc % or less (phase 1 – see dehydration phases below) has been accepted by the macadamia industry as a safe condition for temporary on-farm storage and delivery to a processor.

2. Kernel mc%: This is the moisture content of the kernel only. The present mc % standard for the sale of NIS (mostly to the Far East) is 2% kernel mc. This equates to approx. 5.5% - 6% NIS mc.
Farmers who wish to establish the mc % of their NIS must either take a sample to a (their) processor for analysis or do the labourious test (described in Chapter 3.13.1 & Annexure 4A and 4B) in a domestic microwave oven themselves.

However, there are very few South African processors who have the equipment to actually measure the nut-in-shell mc % and almost every moisture content assessment in the industry is done with a computerized moisture balance scale that can only measure the moisture content of the kernel. This instrument is an expensive tool and, although recommended, is usually not affordable to farmers.

Thus, the farmer is given the moisture content of the 'nut in the shell' (kernel) in his sample and not the actual value of the combination of moisture in the kernel and shell.

The 'true' NIS mc % value can at 10% be very close to its actual kernel value (but it can also deviate by up to 10% see Figure 3.3.a NIS vs. shell vs. Kernel mc with ref) and thus the industry has been generally satisfied with its assessment, though many people have an intuitive feeling that some confusion still exists somewhere.

The dynamics that come into play because of the relationship between the size and composition of all of the components of the nut in shell, together with the factors described above concerning the accuracy of laboratory assessment versus actual results, has added to the confusion.

NB! A NIS mc of 8% is a safer value for kernel preservation than 10% NIS mc.

3.12.7 Avoiding Moisture Content Confusion (Calculation Example)

For most processors, an actual mass measurement is not possible after curing as the batch has been cured/dried with other batches from other growers. The criteria then, for a universally fair calculation for establishing moisture loss and the final cured mass, should reflect on the change in the mass of the TKR mc of the sample. Below 13.5% kernel mc, the moisture in the shell can be ignored as its value will not change unless the NIS is dried to extinction.

A reasonably accurate indication of moisture loss in the NIS components can be transparently calculated providing ACCURATE measurements if the following data are recorded (and that should, in any case, be standard industry measurement practice):

i. The initial delivered mass of WIS.
ii. The initial KERNEL mc % (correct sample size) of WIS.
iii. The final kernel mc % (sale price percentage – usually 2% or 1.5%).
iv. The Total Kernel Recovery (TKR) % at 2% or 1.5% kernel mc.

Note: See Chapter 3.13 establishing on-farm pre-delivery data if an indication is required.

Calculation Example:

A measured mass of WIS are cured to cracking moisture content and then weighed as DNIS at 1.5% kernel mc. The mass of small and damaged nuts are rejected prior to cracking to establish the WIS kernel mc % and final TKR %.

The following must be determined:

a) What was the moisture loss in the rejected DNIS?

b) What was the moisture loss in the kernel?

c) What was the moisture loss in the shell?

d) What was the total moisture loss from the WIS to cracking moisture content?

Established Processing Data

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>3.799 kg</td>
<td>2.931 kg</td>
<td>867.2 kg</td>
<td>436.8 kg</td>
<td>245.8 kg</td>
<td>21%</td>
<td>1.5%</td>
<td>773.5 kg (31% x 2495 kg)</td>
</tr>
</tbody>
</table>

Answers

a) Moisture in rejected DNIS

Moisture lost from WIS batch

\[ WIS: 3.799\text{ kg} - \text{DNIS: 2.931 kg} = 867.2\text{ kg} \]

Percentage of rejected DNIS of Total DNIS

\[ \frac{436.8\text{ kg}}{2931.8\text{ kg}} = 14.9\% \]

867.2 kg

Moisture lost in rejected DNIS = 14.9% x 867.2 kg = 129.2 kg

b) Moisture loss from kernel

TKR 31% x DNIS kg = 31% x 2495 kg = 773.5 kg

Kernel wet kg = 773.5 kg x (100% - 1.5%) = 964.4 kg

(100% - 21%)

Moisture loss from kernel = 964.4 kg - 773.5 kg = 190.9 kg

c) Moisture loss from shell

DNIS kg, 2 kg, etc. x DNIS kg, batch low mc at 1.5% wmc:

2.493 kg - 773.5 kg = 1712.5 kg

Moisture in WIS = 1712.5 kg x (15% - 13.5%) = 1884.9 kg

(15% - 21%)

Moisture lost from WIS = 1884.9 kg - 1712.5 kg = 572.4 kg

TKR: 31%  

Note:

This step can be left out if the WIS kernel moisture content is < 13.5%. At this kernel mc % the moisture content in the shell has stabilized at approximately 5.5%.

d) Total Moisture loss from WIS

Moisture lost from rejected DNIS = 129.2 kg

Moisture lost from kernel = 190.9 kg

Moisture loss from shell = 572.4 kg

Chargeable moisture loss from WIS batch = 847.2 kg

Variance: Calculated batch moisture loss in d) with the established moisture loss in item iii. Processing Data = 2.3% (867.2 kg - 847.2 kg / 867.2 kg x 100%).

Sample prepared in laboratory

Moisture Content Analyser
22. (ii) Indefinite Length Bin with End Access Door

![Diagram of Indefinite Length Bin with End Access Door]

22. (iii) Multiple Parallel Bins, Central Duct and Catwalk Arrangement

![Diagram of Multiple Parallel Bins, Central Duct and Catwalk Arrangement]

22. (iv) Mobile Bin with Detachable Base

![Diagram of Mobile Bin with Detachable Base]

5.4.3 BUNGAY Curing System Philosophy

The correct curing of macadamias is of fundamental importance to their safe quality preservation and long shelf life.

The BUNGAY curing system philosophy applies to four fundamental design principles:

1. Quality preservation. Macadamia harvest quality must be preserved during the curing (dehydration) process which must achieve the desired accurate and uniform final moisture content for every nut in the batch. Curing - low temperature EMC processing - between 25°C and 35°C (Maximum 40°C) – at an optimum intergranular air speed to achieve a consistent and predictable dehydration time and an accurate final NIS mc.

2. Low operational cost. The applied energy source(s) must be as green as practically possible and the electrical energy cost must be highly efficient and limited, as far as possible, to unavoidable essential processing equipment.

3. Low capital investment. The application of capital equipment must be fully utilized during the season and comply with design parameters. That is: No over-design of transformer, switchgear and cable sizes, fans, only purpose-designed machines, handling equipment and controls. All equipment (and noise) installed in a closed, aesthetically pleasing non-ostentatious building consistent, predictable production processing times. An increase in bin turn-around time requires an additional capital infrastructure.

4. Management and maintenance easy. Operator input and PLC SCADA controls must be friendly and allow for devoted attention by the operator to achieve quality macadamia processing without the distraction of the maintenance and labour requirements of ancillary equipment and functions such as those associated with boilers.

Figure 5.8 Macadamia Flow: On-farm to Processor, illustrates the many post-harvest events necessary to consider in the processing of macadamias and the relevance and timing of several drying and storage regimes that must be considered and correctly installed to deliver an optimum product.

5.4.4 Bin Size and Numbers

The ideal...

The complexity of the curing and storage system design (see Figure 5.8) will depend on the size of the harvest and the storage requirements both in terms of volume and time. These factors determine an almost infinite variety of arrangements at each site and it is the individual farmer who must make the final decision.

On-farm bin size determination is based on a combination of:

i. The peak rate of the harvest at 7 days interval determined by the bell curve (Figure 5.9).
ii. The number (if any) different cultivars that must be kept separate and
iii. The on-farm storage duration required prior to the expeditious delivery to the processor.

The guiding principle for on-farm curing and storage systems should include:

a) A single insulated room to manage all the nuts being cured (applying both the ‘flywheel’ effect and the advantage of a low building surface area to volume ratio. The same reasoning applies to nuts in storage).
b) The correct size of bins (based on harvest volume and/or preferred delivery volume).
c) Maximum (average) bin height at 2.4m.
d) The correct number of bins.
e) Bins of simple and uncomplicated construction.
3. Spiral and spring-loaded chain type

These new generation machines are quite efficient and are made with one or more (up to eight) channels allowing for large de-husking capacity and are widely used in the macadamia world. The principle action of the chain is to provide a continuous cutting and peeling of the husk from the shell as it moves down the channel. This dehusker must also be closely adjusted according to performance especially when de-husk thin-shelled cultivars. Waste husk and old hollow nuts fall into a lower, adjustable air stream where they are blown down a chute to outside disposal. The blowing apparatus is an efficient waste husk disposal method that allows for a cleaner working area, but adds quite substantially to the energy operating cost.

Dehusker - Ideal requirements summary

i. Easy loading (from bulk receiving hopper)
ii. Efficient husk removal
iii. No bruising of NIS
iv. No breach of NIS
v. Easy maintenance and spare parts availability
vi. Efficient discharge of waste husk
vii. Energy efficient
viii. ~300kg NIS (600kg NIS) per hour per lane

6.6.2 Potential Impact Risk

Freshly harvested W1H macadamias on-farm still have a good measure of impact protection from poor handling while they are still in their (wet) husk especially if they are hand-harvested. There are, however, several areas of concern regarding impact damage risk, (see Chapter 2.3.11 Impacting Calculations) after de-husking when the NIS no longer has their ‘safety blanket’.

During handling the nuts that fall the furthest – those that are the first to fall - are at the greatest risk of impact damage and bruising. 'Easy let-downs' are essential NIS handling devices used to break the fall of macadamia W1H that are being loaded into bins (or silos). It is all too obvious that the NIS that are bruised in any of the handling processes are thoroughly mixed at every step and there is no way of knowing where these nuts are in the system or the percentage extent of damage to individual nuts or to a batch.

The present general industry mindset is insensitive to impact damage and an abdication of responsibility towards quality and improved shell-life. The macadamia industry, especially at processor level, needs to promote and emphasize the softer handling of NIS and NIS at every stratum of production if pervasive rancidity is to be reduced, shell-life improved and the standard of aesthetic and edible quality raised.

6.6.3 Water Risk

The progress of W1H through a water bath poses little risk to the longevity in quality of macadamia providing that it is a rapid process and that the bulk of the excess water is efficiently removed prior to the curing process. The risk can be lowered if a sterilant is added to the water and this is recommended if the nuts are subject to contamination from animal faces and/or other potentially high microbial risks. The water bath does, however, create the advantage of rinsing off the sticky residue from the nut-in-shell after de-husking. Very wet nut-in-husk.

A potential risk from water immersion (and rain) occurs if NIS are relatively dry after a lengthy wait on the ground awaiting harvest. The shell has become absorbent and may have cracks that allow the water to penetrate to the kernel. The kernel may have shrunk creating a space between it and the shell where the water will remain resident for an indefinite time. This water, besides leaving a stain (discolouration), will penetrate into the kernel if wounds have been created by insects or (dehusker) bruising. Hydrolytic rancidity will be initiated and is not reversible, but progressive. Hydrolytic Action converts unsaturated oils to saturated fats.

Wet NIS are an ideal substrate for the growth of moulds.

The practice of maturity sorting using repeated immersions in water adds to risk of shell-life loss and is not recommended, (Chapter 3.9 Density Sorting).

6.6.4 High Temperature Risk

Nuts that have been potentially bruised (broken kernel cells) are at immediate risk of oil leakage from cells on the surface or deep within the kernel. The speed of the flow of oil from damaged cells will depend on the viscosity of the oil that will decrease with an increase in temperature. Oil causes discolorations on the surface of the kernel especially at higher temperatures. The exposure of the spread of oil on the surface of the kernel to oxygen rapidly initiates irreversible rancidity.

Macadamia NIS curing (to cracking moisture) should preferably not exceed 35°C but never exceed 45°C. Macadamia kernels (out of the shell) may be subjected to short periods (maximum 24 hours) of high temperature @ ±55°C provided that they have sufficient moisture for unrestricted evaporative cooling (@ < 30°C).
6.8.10 PAC's (Precision Air Classifiers/aspirators)

The PAC has become an essential part of equipment used for both de-husking on farm and sorting kernel from shell after cracking at the processor. The principle is relatively simple and is based on the aerodynamic response of size and shape (aerodynamics) of particles passing through a funnelled air stream. Particles such as pieces of husk or shell are both light in weight and have a relatively large surface area to its thickness. They are easily caught in a high-speed air stream and carried away. Round NIS or whole kernels do not have the aerodynamic surface for the air to easily carry them.

The PAC is typically attached to a square, vertical duct through which a centrifugal blower produces a variable controlled mass and velocity of air that discharges into a cyclone set above it. The particles intended for separation are passed into a chute that passes at an angle through the vertical duct to the other side. Inside the duct, at the entry of the bottom of the chute, a sieve of appropriate size prevents particles from dropping down the chute and into the blower.

The blower air volume (and therefore velocity) can be varied at the blower either by a mechanical (choking) damper on the blower entrance or by altering the speed of the drive motor. In principle, the air velocity can thus be adjusted to separate and carry away the aerodynamic particles into the waiting cyclone.

In practice the actual adjustment of the PAC air velocity takes observation and skill, but a well-designed PAC in the hands of a good operator does a fine job.

Many PAC's observed in their places of operation suffer a design flaw that make them very difficult and sensitive to adjust. If the centrifugal blower is not directly above the vertical duct, but off-set from it with an elbow and the sieved separation duct is too close to the elbow the air flow will not 'shear out' in time and will be concentrated to one side (Figure 6.9).

This means that:

- Only a part of the duct will be available for particle separation, and
- The setting of the mass/velocity flow in the duct will be extremely sensitive and unforgiving.

The PAC efficiency can be improved with the correct placement of a properly designed plenum diffuser base that will enable the duct capacity to be fully utilised for all blower control settings.

![Figure 6.9: Correct installation of PAC](image)

6.8.11 Dry vs Wet Processing

Dry Process

The dry process is the most commonly employed method of processing macadamias in the world today. Dried or cured NIS, after cracking, are passed through a PAC (or series of PAC's) to separate shell from kernel (see above). The process output from the PAC is fed onto a conveyor and/or a series of sifting trays where after further sorting takes place optically by hand and/or colour sorter. Macadamia kernels that are deemed to be of quality are then graded and packaged.

The dry process has several advantages:

- It is straightforward, easily implemented and fast.
- It requires the minimum of space and capital investment into machinery.
- It requires no water or additional energy (for drying).
- No additional specialized management skills are required.

The disadvantages of the dry process:

- PAC's are not efficient at removing (especially) small pieces of shell.
- PAC's generate static electric forces on the passing kernel that attracts fine dust particles to the kernel.
- Dust and other fine particles resulting from the cracking process become attached to the (invisible to the eye) oil that has oozed from bruised or otherwise damaged kernels and coated the kernel surface.
- The dry process tends to deliver kernels with an aesthetically displeasing, dusty appearance. Dusty kernels are more difficult for colour sorters to 'read' and also increase the challenges for sorting for defects further down the process.
- The potential for airborne mould spores and bacteria to attach themselves to the dust and oil on the kernels in this circumstance is also high.
- Dry processing cannot detect immature kernels.
- The buyer/value adding processor has to contend with the dust and other particles attached to the kernels (by static forces and/or seeping oil).

6.8.12 Continuous Wet Process

The wet process is a method of sorting macadamia in a brine solution of specific density (typically 1.02) to 'float' the less dense mature kernel and separate it from the dense immature kernel and shell pieces. After cracking the mixture of shell and kernel is fed via conveyor into the brine where the dense pieces sink to a bottom scavenging conveyor that removes them from the building. The 'floaters' are driven from their entry point by a pumped flow of water at the surface of the brine tank to its opposite end where they are recovered for further processing. The wet process was found to be extremely cost effective especially for sorting smaller kernel styles from an infinite number of small shell pieces.

The wet method probably had its origin in Australia, but the development to its present mature phase is a tribute to the several South African processors that continue to employ this method for all their macadamia processing.

In the early 1990's, when South Africa was taking its first steps into macadamia production and processing, the wet process was considered a hazard to the quality and shelf-life of the vulnerable kernel. It was quite common to hear international voices that deprecated the method and who actively advised buyers against buying macadamias processed by the wet method.
CHAPTER 7: Macadamia Business Management

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7.1 Records
7.1.1 Physical Records
7.1.2 Stock-on-Hand Inventory
7.1.3 Fixed Improvements Inventory
7.1.4 Movable Assets Inventory
7.1.5 Labour Records

7.2 Financial Records

7.3 Enterprise Analysis

7.4 Gross Margin System of Analysis
7.4.1 Gross Production Output Value
7.4.2 Directly Allocated Variable Costs
7.4.3 Gross Margin
7.4.4 Net Farm Income
7.4.5 Farm Profit

7.5 Gross Margin Budgeting
7.5.1 Table 7.1: Macadamia Establishment Costs Year 1

7.6 Factors Affecting Macadamia Profitability

7.7 The Cost of a Macadamia Curing and Storage System
7.7.1 A Substantial Investment
7.7.2 The Processor’s Requirements
7.7.3 Sources of Unsound Kernel
7.7.4 Post-harvest Safety
7.7.5 Suppliers of Equipment
7.7.6 Why Spend Money on Equipment
7.7.7 Deciding How Much to Spend
7.7.8 Scenarios

7.8 On-Farm Processing Establishment