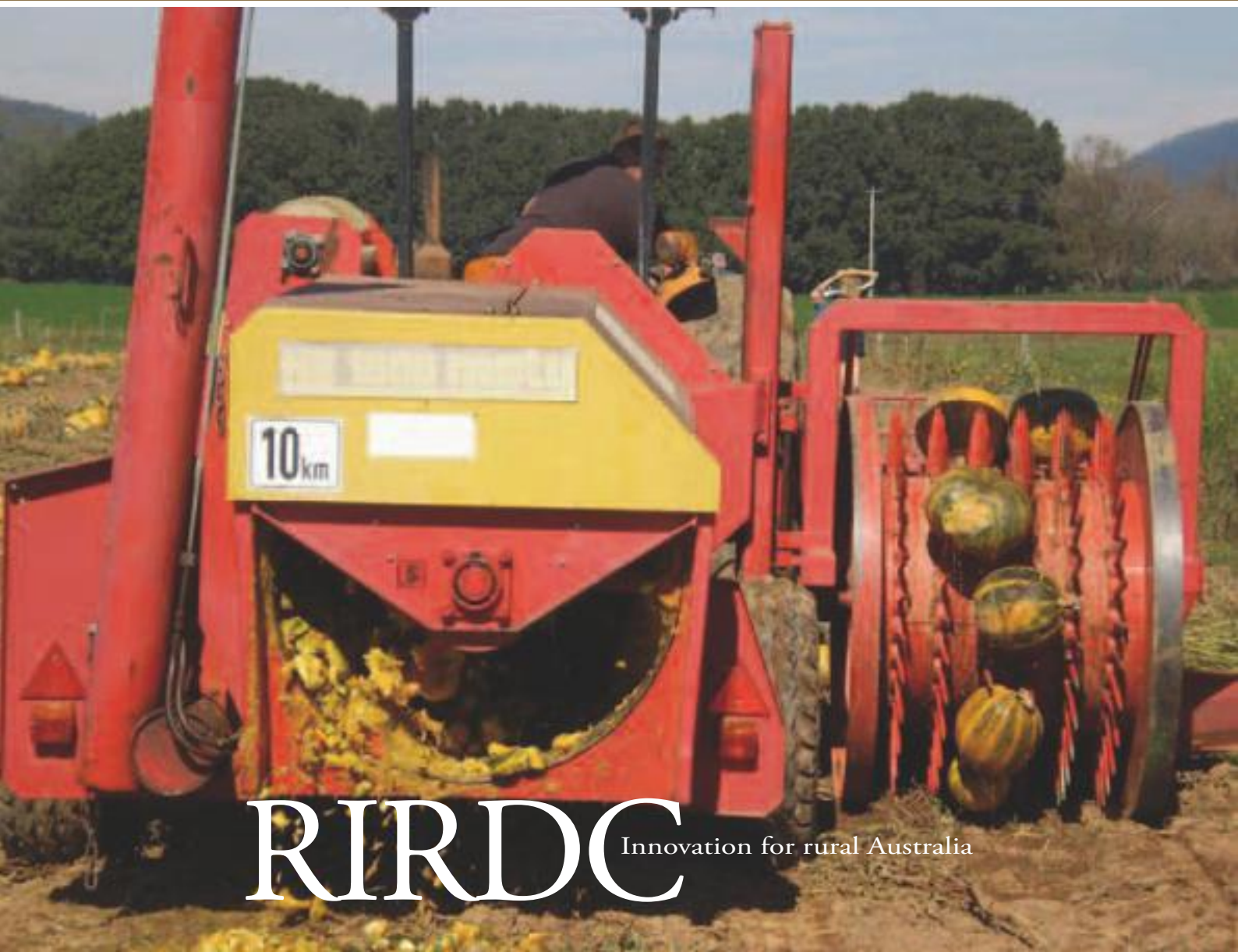




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The Potential to Produce Pumpkin Seed for Processing in North East Victoria

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RIRDC Innovation for rural Australia



Australian Government

**Rural Industries Research and
Development Corporation**

The Potential to Produce Pumpkin Seed for Processing in North East Victoria

by G.G. Baxter, K. Murphy and A. Paech

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Foreword

An established pumpkin seed processing company, looking to source additional Australian-grown pumpkin seed for its operation, has identified a number of potential future production areas, including the north east of Victoria. For farmers on ex-tobacco farms in the Ovens, King and Kiewa valleys, their conversion to the production of pumpkin seed potentially fits well with their region and circumstances.

Like any farmers wishing to diversify or find alternatives to a crop-based industry that has faced closure, these farmers need good information on the agronomy of a potential new crop, the suitability of their area and circumstances for producing that crop, and information about potential markets. Prior to this study, there was little information published on the potential of an edible pumpkin seed industry in Australia.

Most edible pumpkin seed and pumpkin seed products currently available in Australia are reliant on imported product. Australian production of a quality assured health product could lead to a niche field crop that has potential for value adding. Such an industry would appear to potentially fit very well with this part of Victoria, and may also be of interest to growers elsewhere who have access to similarly suitable conditions.

This study is predominantly based on a desktop review but also includes a field demonstration at Myrtleford in North East Victoria.

A clear conclusion from the study is that Australian production of high quality edible pumpkin seed is possible. However, from this study it would appear that additional tuning of establishment, management and harvesting would need to take place for this to be an economically attractive crop for growers.

This project was funded from RIRDC Core Funds which are provided by the Australian Government. TAFCO Rural Supplies, the Rural City of Wangaratta and the Alpine Shire also contributed financially to this project.

This report is an addition to RIRDC's diverse range of over 2000 research publications and it forms part of our New Plant Products R&D program, which aims to facilitate the development of new industries based on plants or plant products that have commercial potential for Australia.

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Craig Burns
Managing Director
Rural Industries Research and Development Corporation

About the Authors

Gary Baxter is currently Project Leader for a Caring for Our Country project dealing with land use change in North East Victoria. He was formerly an employee of the Victorian Department of Primary Industries and conducted research and extension activities with the Victorian tobacco industry until it closed in 2006. He has extensive research and extension experience in row crop production in North East Victoria and is familiar with issues relating to soil, water and climate in that area. Since the demise of the Victorian tobacco industry he has worked with former tobacco growers as they have attempted to develop new enterprises. He also has an intimate insight into some of the social ramifications associated with the loss of a major agricultural industry in a rural community. This has included dealing with the difficulties of developing new ideas into successful enterprises. As the Principal Investigator Gary had a key role in developing and maintaining the linkages necessary to facilitate the project.

Kerry Murphy is Secretary to the TAFCO Rural Supplies Board of Directors and the Myrtleford Chamber of Commerce & Industry. She has extensive experience in project management, and experience in commercial business, strategic planning, governance, leadership and community engagement. She has broad networks throughout the agricultural and business sector and has developed close relationships with local government economic development departments. Her facilitation capacity has brought various stakeholders together to support the current project.

Ashley Paech is an employee of the Department of Primary Industries Victoria where he is a member of the Agribusiness Group. Ashley has been focussing on the area of change and adjustment in rural communities since 2008 and has worked closely with former tobacco growers in the Alpine Valleys during this time. Ashley brings to this project expertise in business strategy and in particular marketing and value chain analysis.

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Lachlan Campbell (Executive Officer, Australian Alpine Valleys Agribusiness Forum)

The Australian Pumpkin Seed Company provided the impetus for the project including their knowledge and information relevant to the production of edible pumpkin seed. This project was developed as an outcome of their visit to Myrtleford in 2009.

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Executive Summary

Various pumpkin cultivars are grown in Australia. Predominantly this production is for the supply of flesh for the fresh produce market. Gaining an improved understanding of pumpkin seed production and processing and speculation on the viability of Australian production was the basis of this project. Whilst there are some quite detailed international reports available on various aspects of the pumpkin seed industry this report aimed to set the scene for a possible Australian industry.

What the report is about

This report summarises the background and intricacies of edible pumpkin seed production and processing. Only limited quantities of pumpkin seed products currently available in Australia are derived from Australian production. There are a small number of precedents where both production and value adding are occurring. This report includes preliminary market research and value chain analysis and offers recommendations on the potential for production in Australia. Pumpkin seed has been a significant food product in some cultures for hundreds of years. With many Australian consumers looking for new food products and culinary experiences Australian production and value adding of edible pumpkin seed could be a niche industry that can be further developed. Australian production may also accommodate consumers who specifically seek Australian grown product and perhaps may be willing to pay a premium price. The opportunity to expand Australian production of pumpkin seed products is the reason the current project is important.

Who the report is targeted at

The original intent of this study, and the impetus to the current project, was to focus on the potential for hull-less pumpkin seed production in Australia. The study aimed to develop a knowledge base for the small number of Australian farmers currently growing hull-less seed cultivars, and from this establish a potential for expanded production. Pumpkin seed sold for consumption in Australia is predominantly imported and largely derived from hulled seed types hence the report also acknowledges aspects of the hulled pumpkin seed industry. Pumpkin seed and other products derived from it could represent a relatively new food experience for many consumers in Australia. Some products may even have the potential to excite chefs and foodies. Therefore, whilst this report is predominantly targeted at potential producers it may also be of interest to seed processors and even epicureans. Farmers in North East Victoria were a key focus of aspects of the current study. There was an underlying objective to use the project process as an example or model for these farmers to assess the potential of a range of new opportunities.

Where are the relevant industries located in Australia?

There are no significant publicised production areas of edible pumpkin seed in Australia. This project was initially developed because a Queensland processing company assessed North East Victoria as a potential production area for pumpkin cultivars with the hull-less seed trait. The company had been investigating the suitability of various locations to grow hull-less seed cultivars and were interested in the cool climate attributes of some areas of North East Victoria. The company had been growing hull-less cultivars themselves in the Chinchilla region of Queensland since the late 1990's. They had also been involved in production trials near Wellington in New South Wales and at a site in Tasmania.

Background

The North East Victoria connection to this study began when a meeting was conducted in Myrtleford during 2009 to gauge interest in trial plantings of hull-less pumpkin seed cultivars. The farmers who expressed interest in a trial were predominantly former tobacco farmers. This was an important link to the current study because in October 2006 the Victorian tobacco industry closed. The last Victorian tobacco crop was grown on approximately 1500 hectares in North East Victoria on highly productive irrigated land along the Ovens, King and Kiewa Rivers and their tributaries. Up to an additional 2500 hectares of land in the same area had also been used to produce tobacco at some time prior to the 2006 industry closure. Since 2006, many former tobacco growing families have been exploring new land use opportunities. Board members of TAFCO, a Myrtleford based rural retail business, sought assistance for the current project to support the farmers who were interested in the hull-less pumpkin seed growing trial. This project has a good regional fit because there is available land, a company keen to purchase seed, and potential producers highly skilled in horticulture crop management. Despite the North East Victoria connection being the impetus for the current project there is no inference that this region is the only area for growing hull-less pumpkin seed cultivars. The reality is that the Upper Valleys of North East Victoria are not historically a cucurbit production area. Other areas across Australia may also be suitable for enterprises relating to pumpkin seed production.

Aims/Objectives

The aim of this one year study was to investigate the potential for establishing a commercially viable pumpkin seed industry in Australia. The prime objective was to better understand the value chain of the industry from production through to processing and retailing. This was done by mapping the value chain, describing the processes and procedures involved and gathering information from international research to help all parties, including former tobacco growers, better understand the industry. A secondary objective of the project was to demonstrate to farmers the process for scoping new industries in order to diversify their production systems. The project had three key activities:

1. Conduct a desktop review in order to offer recommendations on the potential for establishing an edible pumpkin seed industry in North East Victoria and wider Australia, including producing, processing and retailing
2. Investigate current industry knowledge on cucurbit production and assess the limitations specific to former tobacco growing regions in North East Victoria
3. Demonstrate the practicality of growing a semi-commercial block of a hull-less pumpkin seed cultivar whilst assessing specific mechanisation aspects of the seed harvesting, washing and drying processes.

Methodology

A desktop study including preliminary market research and value chain analysis was used in developing recommendations on the potential for Australian pumpkin seed production. The completed report includes detail on the background and intricacies of the international pumpkin seed industry. The report is a tangible output of the project that will enable prospective pumpkin seed producers or processors to develop basic industry knowledge.

Guidelines for growing cucurbit crops in North East Victoria were developed to help build general knowledge of the industry, in particular amongst former tobacco growers in the region. These farmers have little commercial experience with cucurbit production. A collaborative study was conducted in co-operation with staff from the Department of Primary Industry (VIC) and Vegetable Growers Association of Victoria to develop the guidelines. Networks of industry contacts that could assist with agronomic knowledge or help develop strategies that relate to potential production limitations were

developed. A timetable of newsletters, meetings and farm walks were used to articulate information to interested landowners, local and state government groups, and funding organisation representatives. The research organisation has retained evidence of the activity including agronomy notes and quality assurance parameters for pumpkin seed products.

A field demonstration was conducted with the co-operation of a Myrtleford farmer who established and managed a hull-less pumpkin cultivar production area. A semi commercial block utilising three planting dates from mid-November 2010 to early January 2011 was established. The block was managed utilising agronomic and industry data developed during the current project. The demonstration identified challenges and viability constraints that could influence the likelihood of an expanded Australian industry.

Results/key findings

The desktop review has established that theoretically, the production of edible pumpkin seed is feasible in Australian conditions. Existing experience and the semi commercial demonstration block at Myrtleford North East Victoria also confirmed the feasibility. The question of whether an Australian edible pumpkin seed production industry can be scaled up relates to market potential and the competitiveness of Australian product with world markets.

This project has established some baseline information on the use and production of pumpkin seed as an edible food source or processing entity in Australia. Some of the background of international pumpkin seed production summarised to qualify questions relating to a potential Australian production industry. Basic agronomic practices for cucurbit production were assessed as part of the current study. These were incorporated into a semi commercial demonstration block in the former tobacco production area of Myrtleford in North East Victoria. The demonstration block was established and managed by a skilled horticulturalist without previous cucurbit experience. The Myrtleford area is not a recognised cucurbit production area.

Significant quantities of pumpkin seed are available on world markets. Some of this seed is derived from the cultivation of pumpkin cultivars grown specifically to harvest the seed. A proportion of it results as a by-product of pumpkin flesh production. Viable Australian production of pumpkin seed would require a scale that could incorporate mechanisation. This would need to occur in conjunction with well managed field practices and the use of high seed yielding varieties. Another platform on which Australian pumpkin seed production could potentially compete with imported product is by establishing and marketing some point of difference. A seed type or seed quality attribute could be potential points of difference.

Considerable effort was made in this project to highlight the use of hull-less pumpkin seed cultivars as a source of edible pumpkin seed in Australian conditions. This feature is a clear point of difference that may contribute to the niche aspects of the crop and in turn contribute to viability for Australian producers. Dark coloured pumpkin seed oil is produced from this seed type in Central Europe. Oil production is a significant industry in Europe but the seed can also be used as a snack food and for many other purposes. Significant research has been undertaken in Central Europe to develop cultivars that produce seed with yield or quality attributes that make it a widely produced and keenly marketed commodity.

It is difficult to nominate a preferred geographical location for edible pumpkin seed production in Australia based on the current study. There is little doubt that expertise in traditional cucurbit production areas would lend itself well to edible seed production if viability could be proven. Some farmers with this expertise would have the industry knowledge and equipment to cope well with seed production. On the other hand, publications originating from Central European 'oil pumpkin' production areas, routinely link pumpkin seed oil quality to the climatic attributes of the area. This outlook will need to be assessed further under Australian conditions if oil is the production aim. It

could ultimately mean that production may in fact be better suited to some geographical areas that are not currently mainstream cucurbit production areas.

In some respects the use of Australian grown pumpkin seed or pumpkin seed products will be a marketing exercise. This in turn will have an impact on the likelihood of an expansion in field production. The pumpkin seed oil for example is a specialist product. Whilst common in some European countries, it is a relatively new food experience in Australia and so may have the potential to excite chefs, epicureans and foodies. On the other hand, the nutritional attributes of pumpkin seed and its increasing use in the pharmaceutical industry are also grounds to further examine the benefits of Australian production more generally.

Implications for relevant stakeholders

While the question as to whether pumpkin seed production is a viable pursuit for Australian producers remains unanswered, experience from the current study would indicate a production cost of \$6 per kilo may be attainable, but costs around or above \$10 per kilo are likely without considerably more development.

A desire by consumers to 'Buy Australian' may allow growers to achieve a higher price on the Australian market. If a 'Buy Australian' platform could achieve a premium price, the implications for future expansion of production and processing are more encouraging.

The study has highlighted that there are cultivars available internationally that have been developed specifically for high seed yield or a nutritional attribute. Maximising seed yield would be critical for any Australian pumpkin seed producer. This is because the difficulty competing on price with imported pumpkin seed would be exacerbated by low yield in Australian production situations. Internationally, there are research programs that deal exclusively with maximising the yield and quality attributes of pumpkin seed production. There is undoubtedly much to be learnt through collaboration with some of these organisations or other key industry personnel. Such interaction could provide breakthrough technologies that would enable quantum improvement in current field production or value adding techniques. If the combinations of high yield, high quality attributes, and quality assurance could be linked with a 'Buy Australian' philosophy, the genesis of an expanded local production and processing pumpkin seed industry could be in the offing.

This study has emphasised the difficulties of developing a new enterprise. Pumpkin seed as a commodity was new to the North East region of Victoria and new to the farmers who cooperated with the demonstration trial. There was a sound platform that helped initiate the current project because there was a willing purchaser who wanted Australian product grown in a cool climate location and a group of highly experienced farmers who had had extensive expertise in irrigated row crop production. The purchaser-producer link was important in this instance to help establish a demonstration block in a new production area. Instant viability is elusive. Perseverance and a thirst for knowledge will be critical to maintain the momentum for a broader Australian pumpkin seed production industry.

This study is an example of an endeavour that would benefit from continued recognition by government at all levels. There is a good mix of production potential, a healthy product, and even tourism opportunities. The study has clearly demonstrated that new diversification presents considerable challenges to landholders, processors and marketers. In the case of former tobacco farmers in North East Victoria, only a small number have shown a willingness to try new production pursuits; they have been risk averse. Realistically these farmers are not going to compete with established horticultural production enterprises in mainstream vegetable and fruit crops because generally their farm size is unsuitable, they lack industry experience, and markets are difficult to penetrate. Therefore, a new niche type activity such as pumpkin seed production would be a good fit for the area, but only if viability can be demonstrated. Recognition by government is a reason why the

current project was a good one. It enabled knowledge to be developed whilst support could be provided for a field demonstration. Without future support, production of pumpkin seed in North East Victoria area, and perhaps more broadly, could falter quickly because career farmers are generally unwilling to persist with new production pursuits if returns do not quickly accompany their risk. Therefore, this project has been a useful model for landowners in North East Victoria because it has given an insight into some of the problems confronting farmers who want to diversify. If commercial pumpkin seed production is to continue or expand further, work needs to be undertaken in a range of areas.

Recommendations

Dedicated edible pumpkin seed production is currently not a significant industry in Australia. Therefore, almost every aspect of Australian pumpkin seed production, processing and marketing could potentially benefit through collaboration with key research and industry personnel from recognised international production areas. Based on this project *The Potential to Produce Processing Pumpkin Seed in North East Victoria*, it is recommended that the following future activities be undertaken or considered as part of the process to assist development of an edible pumpkin seed production industry in Australia:

- Assess hull-less pumpkin seed cultivars originating from European ‘oil pumpkin’ plant breeding programs. High yield could be a useful risk management strategy for potential Australian producers. [Late in the current study the authors became aware that a privately owned plant breeding company based in New Zealand has been developing and trialling hybrid hull-less seed pumpkin cultivars for the European ‘oil pumpkin’ industry. Collaboration with this company should be considered].
- Assess pumpkin cultivars originating from the University of New Hampshire plant breeding program for the production of pumpkin snack seed. Cultivars developed from the University program are reputed to be higher seed yielding than the European ‘oil pumpkin’ cultivars. [It is important to note that the United States pumpkin snack seed market is quite different to the European ‘oil pumpkin’ seed market].
- Refine agronomic practices relating to the production of edible pumpkin seed. This would be particularly relevant if introductions of new cultivars occurred. Practices that require improvement include plant spacing layouts as well as the interaction of plant nutrition with seed quality.
- Benchmark the chemical composition of Australian grown pumpkin seed. This benchmarking would measure variability in chemical attributes across cultivars and determine if there are potential benefits through cultivar selection. Australian pumpkin seed chemical data would build knowledge on cultivar and environmental interactions as well as being a useful comparison to European analyses.
- Develop protocols for the post-harvest and handling of harvested pumpkin seed. This should include precise detail on seed washing procedures, seed drying temperature and seed storage requirements.
- Conduct a study tour to examine aspects of the Central European ‘oil pumpkin’ industry. Study parameters should include agronomic practices, the processing industry, marketing strategies and current research including cultivar development and seed chemistry. (Collaboration with the one known ‘oil pumpkin’ producer in New Zealand could be a useful endeavour too).
- Develop project proposals to secure ongoing support and commitment from government so commercial edible pumpkin seed production and processing can be further assessed and developed.

- Use this project as a model for former North East Victorian tobacco growers to examine other new and /or niche crops for the area.
- Examine aspects of pumpkin seed quality assurance. This should include an investigation of whether past pesticide use may impact on pumpkin seed acceptability. It should also include discussions with the Australian Pesticides and Veterinary Medicines Authority and Food Standards Australia New Zealand relating to the appropriate classification category for pumpkin seed and pumpkin seed commodities (such as oil). This would help determine if existing Maximum Residue Limits apply or if the establishment of Extraneous Residue Limits (ERL) are necessary.

Introduction

This project was initiated when a Queensland processing company, searching for suitable locations for growing a unique cultivar of pumpkin, identified North East Victoria as a potential cool climate location. The company was interested in new production sites so seed could be harvested and used to develop edible pumpkin seed products. The North East Victoria connection to the current study began after a meeting to gauge interest in a trial planting of the pumpkin cultivar was conducted in Myrtleford during 2009. The cool climate attributes and the availability of irrigated arable land in the Upper River Valleys of North East Victoria were the principle reasons behind the Myrtleford meeting. The pumpkin cultivar in question had previously been grown by the company in the Chinchilla region of Queensland. There had also been production trials in New South Wales and Tasmanian locations. One of the founders of the company grew up in the country of Slovenia in Central Europe. In this region cultivation of the pumpkin cultivar was common. His passion has led to the development of a family business in Australia.

The Queensland processing company was interested in the unique characteristic of the pumpkin cultivar. It relates to the seed which is referred to as a naked or hull-less type. Pumpkin cultivars with this seed characteristic are widely grown in Central Europe where they have been used for over one hundred years to produce seed that is pressed to extract oil. The cultivars are also often referred to as 'oil pumpkins' in Central Europe and the oil is highly sort after for its culinary and medicinal uses. Although the Queensland company have grown the cultivar and harvested their own seed, they have also relied on some imported seed to ensure sufficient seed for processing. The company has been keen to source a quality assured Australian grown product. Although there has been sporadic Australian production of pumpkin cultivars to produce hull-less seed there is little evidence that commercial field plantings of any significant scale is occurring.

The farmers who attended the Myrtleford meeting during 2009, and expressed the greatest interest in a production trial, were former tobacco farmers. This is an important link to the current study because in October 2006 the Victorian tobacco industry, which was centred in the area, closed down suddenly. The last Victorian tobacco crop was grown on approximately 1500 hectares of highly productive irrigated land along the Ovens, King and Kiewa Rivers and their tributaries. Up to an additional 2500 hectares of land in the same general geographical vicinities, had also been used to produce tobacco at some time prior to the 2006 industry closure. Many former tobacco growing families had been conducting and exploring new land use options at the time of the meeting. Board members of a Myrtleford based rural retail business initiated the current project to help support regional farmers investigate new enterprises. In seeking support for the current project there was also an underlying objective to rebuild farmer confidence and improve the capacity of landowners in the assessment of new opportunities. It was clear that the project had a role in maintaining a strong social cohesiveness across the Valleys of the Upper Ovens, King and Kiewa River systems. This was evident because a number of meetings and farm walks relating to the project were conducted. They were well attended. Although speculative production of pumpkins has occurred in these former tobacco production areas, historically no cucurbit industry of significance has ever been established.

This study focuses largely on hull-less pumpkin seed cultivars. As the project proceeded it became clear that there is an abundance of pumpkin seed types available on world markets. Price variability in these markets is significant. It is unlikely that Australian producers are going to compete in these world markets on price alone. This is particularly so because significant quantities of the pumpkin seed that is available on world markets is effectively a waste product emanating from pumpkin flesh production. Viable Australian production of pumpkin seed suited for the snack seed or processing market would therefore require a point of difference. Hence, considerable effort has been taken to highlight the use of hull-less pumpkin seed cultivars because that feature is a clear point of difference that may contribute to the niche aspects of the crop. In some respects the use of Australian grown pumpkin seed and pumpkin seed products will be a marketing exercise. The pumpkin seed oil for

example is a specialist product. Whilst common in some European countries, it is a relatively new food experience in Australia and so may have the potential to excite the food industry.

Aims/Objectives

The aim of this study was to investigate the potential for establishing a commercially viable pumpkin seed industry in Australia. The objective was to better understand the value chain of the industry from production through to processing and retailing. This was done by mapping the chain, describing the processes and procedures involved and sourcing information from international research to help potential industry participants better understand the industry. A secondary objective of the project was to demonstrate to farmers the process for scoping new industries in order to diversify their production systems. The project had three key activities:

1. Conduct a desktop review in order to offer recommendations on the potential for establishing an edible pumpkin seed industry in North East Victoria and wider Australia, including producing, processing and retailing
2. Investigate current industry knowledge on cucurbit production and assess the limitations specific to former tobacco growing regions in North East Victoria
3. Demonstrate the practicality of growing a semi-commercial block of a hull-less pumpkin seed cultivar whilst assessing specific mechanisation aspects of the seed harvesting, washing and drying processes

Methodology

Conduct a desktop review in order to offer recommendations on the potential for establishing an edible pumpkin seed industry in North East Victoria and wider Australia, including producing, processing and retailing

A desktop study including preliminary market research and value chain analysis was conducted. A detailed summary of the background relating to the use of hull-less pumpkin seed was a necessary platform to set the scene for an assessment of production viability in Australian conditions. cursory mention was also made of the normal hulled type of edible pumpkin seed. Language considerations and tightly held industry information restricted aspects of the study relating to hull-less pumpkin seed. Effort was made to determine the key people involved with production research relating to edible pumpkin seed. The desktop study was the principle activity contributing to an assessment of potential for expanded Australian production of edible pumpkin seed. The completed report includes detail on the background and intricacies of the international pumpkin seed industry. The report is a tangible project output that will enable prospective pumpkin seed producers or processors to develop basic industry knowledge.

Investigate industry knowledge on cucurbit production and assess the limitations specific to production in former tobacco production areas of North East Victoria

The activity was largely conducted as an extension endeavour. A collaborative study was conducted in co-operation with Department of Primary Industry (VIC) and Vegetable Growers Association of Victoria staff to develop cucurbit production guidelines specific to North East Victoria. This occurred because the field demonstration component of the project was being conducted by former tobacco farmers in North East Victoria. These farmers have little commercial experience with cucurbit production. Therefore, networks of industry contacts that could assist with agronomic knowledge or help develop strategies that relate to potential production limitations were developed. A timetable of newsletters, meetings and farm walks were used to articulate aspects of the information to interested landowners, local and State Government groups, and funding organisation representatives. The research organisation has retained evidence of the activity including agronomy notes and quality assurance parameters for pumpkin seed products.

Demonstrate the practicality of growing a semi-commercial block of a hull-less pumpkin seed cultivar whilst assessing specific mechanisation aspects of the seed harvesting, washing and drying processes

This field demonstration activity required the co-operation of a former tobacco farming family from the Myrtleford area of North East Victoria. The family were experienced farmers and highly skilled in commercial row crop production. They did not have commercial cucurbit production expertise. The semi-commercial block was managed according to agronomic and industry data developed through earlier project activities. Two hull-less pumpkin seed cultivars were planted and three planting dates (from late November 2010 to early January 2011) were utilised. The demonstration enabled the scoping of practical challenges and viability constraints that could influence the likelihood of an expanded Australian industry. Detailed production notes have been retained by the research organisation. A pictorial overview of the demonstration has been included as an Appendix to this report.

Value Chain Analysis

The production, processing and marketing of hull-less pumpkin seeds can be described using a value chain analysis. Each step in the chain, which can be seen in Figure 1, is critical to the viability of a pumpkin seed industry. The following value chain analysis aims to describe each of the key components of the chain and identify key issues and gaps for further investigation. This analysis contributes to the overall recommendations on the potential for an Australian produced edible pumpkin seed industry.

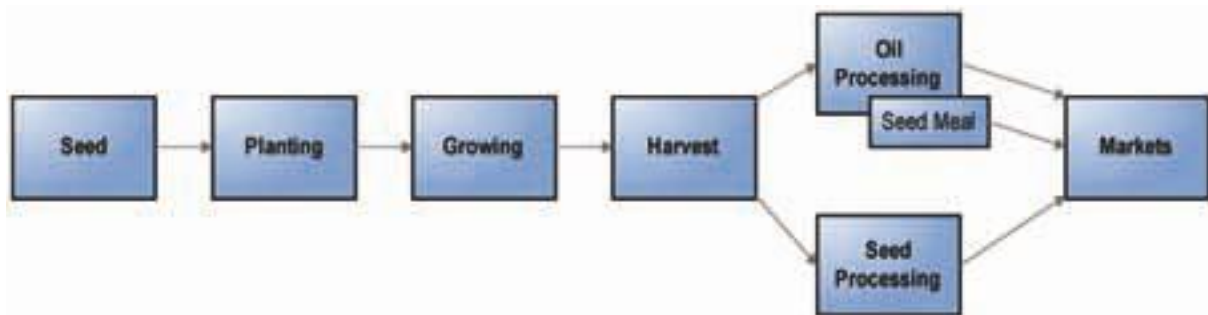


Figure 1: A description of the pumpkin seed value chain

Defining a Pumpkin

The current study broadly relates to the potential for Australian production of edible pumpkin seed that is suitable for either direct use or processing. Prior to any detailed appraisal of seed production, some background on the types of usable pumpkin fruit is necessary. A degree of confusion can occur with terminology because the common name pumpkin is routinely used to include a number of cultivated species.

It is generally accepted that pumpkins belong to the genus *Cucurbita* and the family *Cucurbitaceae*. Terms such as pumpkin, squash, gourd, cushaw and others are often applied to different cultivated *Cucurbita* species. The three most important domesticated species of *Cucurbita* include *C. pepo*, *C. maxima* and *C. moschata*. Other species such as *C. argyrosperma*, *C. mixta* and *C. ficifolia* may also be referred to as pumpkins and are grown commercially in some countries. Terminology will therefore in part depend on a geographical region or in some instances a localised cultural interpretation. The naming problem is further exacerbated by language translations. Many authors have commented on the apparent confusion associated with *Cucurbitaceae* terminology.

...on the one hand the family is extremely polymorphic for size, shape, and colour of the fruits; on the other, the fruits of some cultigens of one species can exhibit great similarity to the fruit of a different species. Often, the result has been different names for the same species and the same name for different species (Paris 2007, p. 354).

The implication from this type of naming confusion is that the word 'pumpkin' is used predominantly as a culinary descriptor rather than a taxonomic classification.

From time to time some authors have suggested using a standardised name such as pumpkin or squash as a generic term for all members of the *Cucurbita* genus. However, most authors concede that the existing popularised terminology is simply too ingrained for change. Therefore, it remains that some of the common name classifications relating to the genus *Cucurbita* will vary depending on the part of the world in which the term is used. This is why common name terminology is important in the context of the current study. For example, a United States based cucurbit specialist, referred to pumpkins as 'large fruited, usually round or oval cultivars grown for ornamental purposes, pie processing, and less commonly for livestock feed, (Loy 2004, p. 338). On the other hand, he used the term squash 'to refer to *Cucurbita* cultivars grown for direct human consumption as a side dish at meals' (Loy 2004, p. 338). This terminology does not always fit well because there are some instances where the fruit of particular *Cucurbita* cultivars can have a number of uses. Ferriol and Pico (2007, p. 317) also referred to pumpkins as 'cultivars producing round fruit which are used when mature for baking or for feeding livestock'. They categorised squashes into summer and winter types (Ferriol and Pico 2007, p. 317). Summer squashes were defined as 'cultivars grown for their edible immature fruits' whilst winter squashes were harvested as 'cultivars grown for their mature fruits that store well and are not usually round' (Ferriol and Pico 2007, p. 317). Using this classification, Loy (2004, p.338) noted that winter squashes would normally include 'acorn (*C. pepo*), buttercup/kabocha (*C. maxima*), and butternut (*C. moschata*)' but conceded there are exceptions because in some cultures 'immature fruit' of cultivars of the same species are eaten. In an Australian context the term pumpkin would normally refer to what many international authors refer to as winter squash.

Even the most rudimentary of studies quickly highlights that a number of *Cucurbita* species are grown commercially to extract seed for culinary use. In fact, Paris (2007, p. 353) reported that 'the first use of *Cucurbita* by people as food appears to have been the consumption of its seeds' rather than flesh. In ancient cultures seed consumption would have been based on wild *Cucurbita* species. Therefore, the concept of utilising pumpkin seed for various culinary uses is not new. 'Pumpkin seeds are also important as snacks, as a source of edible oil and protein for human and animal consumption, and in the pharmaceutical industry' (Ferriol and Pico 2007, p.318).

...there are regions in Mexico where the seeds are still considered the most desirable part of the plant.
...landraces in these regions tend to have fruit that are thin-fleshed with proportionally large seed cavities containing seeds that are generally elongated.
...The seeds may be eaten raw or roasted as a snack seed, commonly called pepitas (Andres 2000, p. 87).

In the United States there is interest in the production of pumpkin cultivars for the harvest of seed destined for the snack seed trade (¹J. Brent Loy, pers. comm., 2 February 2011) but the cost of production compared to the price of imported seed has likely been a disincentive. Loy (2004, p. 353) said 'pumpkin seeds are consumed throughout the world' but 'the commercial market for pumpkin seeds is still relatively small'. In areas of Central and Eastern Europe, but particularly in the Austrian province of Styria, pumpkins are also commercially cultivated to extract the seed. In this latter instance the seed is usually a hull-less type and predominately utilised to produce edible oil. Many references that discuss cultivars with the hull-less seed trait simply refer to them as 'oil pumpkins'. The quest for detail on edible pumpkin seed production quickly highlighted the importance of associating a geographical region with an end use. This is because some groups refer to pumpkin seed purely as a snack food product whilst others use the seed almost exclusively for the production of edible oil. It should now be evident why it has been important to explain some of the variation in terminology relating to the term pumpkin. The word pumpkin will be used for the remainder of this text. Likewise, a detailed species and cultivar description will be equally important.

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Seed Types

Hull-Less Pumpkin Seed

Loy (2004) reported that although the term hull-less is used to describe the unique seed trait that originated in the Styria region of Central Europe, it is actually not a botanical descriptor. This is because there are still actually seed coat layers in hull-less cultivars. There are five seed coat layers in the testa of a ripe hulled seed namely, epidermis, hypodermis, sclerenchyma, arenchyma and chlornchyma (Zraidi, Pachner and Lelley 2003). The mature seed coat is tough and leathery in hulled pumpkin seed cultivars but is reduced 'to a thin, usually greenish membranous-like cover' in the hull-less cultivars (Loy 2004, p. 353).

...In cultivars classed as completely hull-less, the outer seedcoat layers are reduced to the extent that the seed takes on the colour appearance of the inner seedcoat layer which is normally dark green (Loy 1990, p. 404).

In 'oil pumpkin' breeding programs conducted in Central Europe, the dark green colour is a highly sought after characteristic. Zraidi, Pachner and Lelley (2003) conducted a study on the genetics and histology of the hull-less seed trait and also determined that in completely hull-less ripe seed the four upper layers are wholly collapsed, colourless and without any trace of lignin. This seed type has the dark green colour. Zraidi, Pachner and Lelley (2003) contended that some hull-less segregations have degrees of lignification in the seed layers which can lead to thin layers of a clear deposition covering the dark green seed. Lelley, Loy and Murkovic (2009) referred to these as residual lignifications. They compared this hull-less variation to normal *C. pepo* seeds which 'are covered by a thick, leathery, whitish to ochre coat consisting of five layers, of which three are strongly lignified' (Lelley, Loy and Murkovic 2009, p. 475).

Hull-less pumpkin seed requires little heat and pressure to extract oil and there is no requirement for hull removal which is a necessary process with normal hulled seed used in the snack seed trade (Andres 2000). Teppner (2004) reported that the name *Cucurbita pepo* subsp. *pepo* var. *styriaca* I. Greb was given to the Styrian 'oil pumpkin' by a renowned botanist Igor Sergeevic Grebenscikov in 1950. This naming was based on reference to the hull-less seed trait. Oil types of *C. pepo* are also known as *C. giromantiina* var. *oleifera* Pietsch., syn. *C. citrullina* (L.) Greb. var. *styriaca* Greb. (Bavec et al. 2002).

There was an International Oil Pumpkin Conference held in Austria in August 1999. It was organised to exchange and publicise information relating to hull-less seed production and the subsequent oil production. There was intent to use this first International Conference to promote hull-less pumpkin seed products and have them recognised as an entity in their own right. The Conference attracted participants from traditional 'oil pumpkin' production countries in Central and Eastern Europe but also from countries such as Israel, Russia and New Zealand (Lichtenecker and Lelley 2000). A second International Oil Pumpkin Conference was proposed for July 2004 in the Czech Republic but did not occur. No further International Oil Pumpkin Conferences occurred after 1999 and no future Conferences are currently proposed.

The Oil Pumpkin Conference was held in Austria and organised by Austrians because that country or more specifically the Styria region regards itself as the traditional home of pumpkin seed oil production. Lichtenecker and Lelley (2000, p. 86) reported that 'extracting oil from pumpkin seed is a century-old tradition centred in Styria, in the south-eastern part of Austria'. They went on to say, that although the tradition was originally based on physically removing the tough seed hull from the seed prior to oil production, since late in the nineteenth century hull-less or naked seeds have been the mainstay of the Styrian industry. Teppner (2004) conducted a review on *Lagenaria* and *Cucurbita* as a botanical contribution for a German Language book on Halloween folklore. He reported that

definitive historical evidence pointing to cucurbit production in the Styria region dates back to 1697, although far earlier production was likely. Teppner (2004) related detail of four additional references during the 1700's that indicate uses of peeled pumpkin seed and oil in the Styria region. He also went into great detail to set the scene through historical references that cucurbit production, and in fact seed oil production, became commonplace during the 1700's and into the 1800's. Using more detailed harvest statistics from historical data emanating between the years 1874–1880 Teppner (2004) concluded cucurbits together with beans were a significant intercrop in maize fields. Teppner (2004) deduced from these and earlier records that only thick-coated seeds existed. Teppner (2004) drew on earlier references to indicate that in the late 1800's, in much of Styria, pumpkin seeds were immersed in hot water prior to peeling. He did further comment that in the north eastern parts of Styria and some neighboring provinces seeds were not immersed in hot water, but instead pounded along with their seed coat, prior to pressing. Teppner (2004, p. 295) was confident that neither thin-coated seed cultivars nor the hull-less characteristic were likely to have been present during the early to mid-nineteenth century because 'the authors were talented professionals' and would have recorded the trait.

Teppner (2004) reported that the most probable first appearance of the thin-coated seed trait was between 1870 and 1880. Lichtenecker and Lelley (2000, p. 86) refer to this thin-coated seed trait as a 'recessive mutation which prevented the coat of the pumpkin seed from lignifying'. Teppner (2004) speculated that the mutation originated from *Cucurbita pepo* subsp. *pepo* that was commonly grown in Central Europe at the time. Lichtenecker and Lelley (2000, p. 86) reported that 'subsequent selection of the green-seeded plants, homozygous for the mutation, led to the establishment of the ecotype *Cucurbita pepo* var. *styriaca*'. Teppner (2004) stated that records relating to the local seed trade in Styria in 1915 indicated the commercial availability of a naked or hull-less cultivar suited for the preparation of oil; the original named variety was called 869 Feldkurbis.

...Due to the popularity of pumpkin seeds and especially the seed oil, the advantage of the hull-less seed type, allowing a much more efficient oil extraction, was quickly recognized, leading to its rapid dispersal in the whole region (Lelley, Loy and Murkovic 2009, p. 470).

Conscious effort to incorporate the hull-less seed trait with characteristics that would optimise production agriculture led to dedicated plant breeding programs. One of the early resultant varieties was registered with the Federal Institute in Vienna in 1955 and was listed as Tschermaks Ölkürbis (Teppner 2004). Erich von Tschermak-Seysenegg was Professor of Agriculture at the Academy of Agriculture in Vienna Austria. He developed a bush-type hull-less seeded pumpkin, which became universally known as Tschermak's oil-pumpkin, by crossing a Styrian vining (vinous) hull-less oil seed pumpkin with a hulled bush-type squash called Mark Marrow (Winkler 2000).

...Tschermak chose the bush form so that the fruits could mature more rapidly and uniformly and facilitated mechanical weed control. But his type produced smaller fruits and smaller seeds so the farmers still preferred the Styrian hull-less vining pumpkin which they themselves had selected (Winkler 2000, p. 101).

The Tschermak variety produced a smaller lighter coloured seed than the selections from within the traditional 'oil pumpkin' production areas and had some appeal particularly in Germany (Teppner 2004). The hull-less pumpkin seed now used for oil production in the Styria region is an olive-green colour that produces dark coloured oil. You may expect that seed size should not be a critical factor if the end use is oil production, but producers have obviously shown a preference to large seeded cultivars (Loy 2004).

...Breeding to increase the oil content of hull-less seeds of the Styrian vining oil pumpkin was begun in 1940 at the Lamberg Breeding Station near Ilz in the eastern part of Styria (Winkler 2000, p. 101).

This was in the heart of the traditional ‘oil pumpkin’ production area. The first registered cultivar from this program was called Steirischer Schalenloser Ölkürbis (Teppner 2004). It had a vinous growth habit and became universally referred to as a Styrian hull-less ‘oil pumpkin’. In the late 1940’s staff at ‘the Technical University of Graz initiated analyses of oil and protein content of the seeds’ of ‘oil pumpkin’ varieties (Winkler 2000, p. 101).

Loy (1990) indicated that as early as the 1940’s in the United States some researchers had recognised the potential value of the hull-less seed trait. Loy (1990) referred to a researcher called L. C. Curtis who initiated a breeding program at the University of Connecticut that aimed to increase edible seed yields utilising the naked seed trait. The University of New Hampshire in the United States has also conducted pumpkin breeding work utilising the naked seed trait. The hull-less cultivars Sweetnut, Eat-all and Tricky Jack were released by the University of New Hampshire in 1960, 1965 and 1969 respectively (Lelley, Loy, and Murkovic 2009). Later, these were followed by a cultivar called Lady Godiva that was phenotypically very similar to Styrian ‘oil pumpkins’ and released by the United States Department of Agriculture in 1972 (Lelley, Loy, and Murkovic 2009). ‘It was a selection developed from European landraces’ as were subsequent United States cultivars such as Mini-Jack, Streaker, Trickster and Triple Jack (Andres 2000, p. 87). Breeding of semi-bush (bush x vine cross), pumpkin cultivars with the hull-less seed trait is still continuing at the University of New Hampshire. These varieties are being bred to produce roasted seed for the snack seed trade as there is really not a large market for the oil in North America (²J. Brent Loy, pers. comm., 21 July 2010). Hull-less pumpkin seed cultivars developed through the University of New Hampshire program have been licensed to commercial seed production Companies.

Lelley, Loy, and Murkovic (2009) reported that the botanist Igor Sergeevic Grebenscikov was the first researcher to propose that hull-less pumpkin genotypes anywhere in the world are likely to have originated from the Styrian cultivars. Grebenscikov conducted this research in the 1950’s. Andres (2000) acknowledged this hypothesis but reported that thin-seeded specimens of *C. pepo* had been found on rare occasions in Northern Mexico. Lelley, Loy and Murkovic (2009) also discussed a Chinese researcher, Zhou Xianglin, who had reported an occurrence of a hull-less genotype of *C. moschata* in a peer review journal. The hull-less seed of this cultivar was white. This cultivar of *C. moschata* is referred to as Zhou. An English summary of the Zhou (1987) article indicated the naked seed trait of the *C. moschata* cultivar is stably inherited and controlled by a pair of recessive genes.

Several studies on the Austrian hull-less pumpkin seed coat characteristic were carried out in the 1950’s and there was general agreement on the existence of a major dominant gene responsible for strong lignifications of some of the testa layers of the hulled seed type. Zraidi, Pachner and Lelley (2003) supported the Grebenscikov work and subsequent studies and contended that all hull-less phenotypes were very likely to have directly descended from the Austrian ancestor. Lelley, Loy, and Murkovic (2009) concluded that it is also likely that personal selections following the identification of the hull-less trait, plus later breeding efforts, have consciously selected for any modifying genes which have further reduced lignifications of the seed coat.

The importance of pumpkin seed oil, the snack seed trade and even medicinal uses of pumpkin seed products has formalised breeding attempts to improve yield, quality and other parameters (Teppner 2004). Most modern breeding efforts have sought the production of hybrid (F1) cultivars. As a consequence most new cultivars possessing the hull-less trait are hybrid. A number of studies have clearly shown ‘components of seed yield can be increased in F1 hybrids of *C. pepo*’ (Loy 2004, p. 360). He also reported that whilst the genetic basis of this hybrid vigour in seed yield components is yet to be explained it is not inconceivable that the same beneficial traits can be incorporated into open pollinated lines. This is unlikely to occur given that plant breeders have little avenue to generate income from open pollinated varieties. Evidence of breeding work utilising the hull-less trait to

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develop new varieties has been easier to verify from countries such as Austria, Serbia and the United States than in many other countries. Teppner (2004) maintains that all breeding efforts anywhere in the world utilising the thin-coated trait ultimately trace back to Styrian material. However, it has been relatively difficult in the current study to determine the extent of active ‘oil pumpkin’ breeding programs.

Saatzucht Gleisdorf, also known as Gleisdorf Seed, is one Austrian company that has an active plant ‘oil pumpkin’ breeding program. Saatzucht Gleisdorf is attempting to broaden the genetic basis of Styrian hull-less pumpkin seed cultivars. A goal of the company is to maintain the typical characteristics of the Styrian ‘oil pumpkin’, especially with regard to seed formation, seed colour and seed chemical content (Saatzucht Gleisdorf 2010). The company has developed open-pollinated varieties but most recent releases have been hybrid lines. The breeding aims of their program include the development of vinous cultivars which have large, round fruit and high yielding seed characteristics. Also, the company aims to develop cultivars with seed that is easy to extract from the placenta, a high proportion of seed in relation to flesh, a less vinous trait, a high disease resistance and an increased content of valuable chemical components (Saatzucht Gleisdorf 2010). Saatzucht Gleisdorf has initiated additional breeding work since 2003 specifically targeting the expanding organic sector in Central European production areas (Saatzucht Gleisdorf 2010).

It has been difficult to definitively determine if active ‘oil pumpkin’ breeding programs are being conducted by other organisations within Austria. All commercial Austrian varieties must be registered so the following list of registered varieties is probably the most reliable source of commercial ‘oil pumpkin’ cultivars. Five open pollinated and six hybrid cultivars of ‘oil pumpkin’ are registered on the Austrian variety list (AGES 2010). These include the open-pollinated varieties Weis 371, Sepp, Retzer Gold, Markant and Gleisdorfer Ölkürbis. The currently registered hybrid varieties include Gleisdorfer Express, Gleisdorfer Diamant, GL Opal, GL Maximal, GL Kristall and GL Global. Varietal descriptions, including yield performance, growth characteristics and disease resistance ratings, are available for most of the Austrian registered varieties (FOFS 2010). The Austrian varieties are utilised in several countries. For example two cultivars presently used in production in Slovenia are Gleisdorfer Ölkürbis and Wies 371. Other pumpkin cultivars with the hull-less seed trait grown in Slovenia include Slovenska Golica, and Olinka (Bavec et al. 2007). Slovenska Golica is based on a Slovenian selection and Olinka originates from Serbia.

There is an active ‘oil pumpkin’ breeding program in Serbia. There has been three decades of research and development in ‘oil pumpkin’ genetics and breeding at the Institute of Field and Vegetable Crops in Novi Sad, Serbia (Berenji 2000). As a result of this program the vinous hull-less seed variety Olinka was registered in 1992 and the hulled seed bush type variety Olivia was registered in 1997 (Berenji 2000). These varieties have since been registered or utilised in several non-Serbian countries including Slovenia and Hungary. A privately owned plant breeding company based in New Zealand has been developing and trialling hybrid hull-less seed pumpkin cultivars. Hybrid Seed Company New Zealand Ltd has worked commercially with hull-less varieties commercially in many countries of the world and is currently finalising the registration process for a European release of the hybrid ‘oil pumpkin’ cultivar HSC151 (³M. Johnson, pers. comm., 15 December 2010).

Peer reviewed articles occasionally refer to other ‘oil pumpkin’ varieties. Authors of these articles often do not state if these varieties are hull-less seed types nor their country of origin. For example, ‘oil pumpkin’ varieties listed as Miranda, Golosemiannaja and Herakles were inclusions in trials conducted at the University of Lithuania in 2004 and 2005 but there was no reference to seed coat type (Jariene et al. 2007). In this instance it is likely that the three cultivars are in fact the hull-less seed type and have originated from Poland, the Ukraine and Germany respectively. Zraid, Pachner

³ Mark Johnson is a co-owner of the Hybrid Seed Company based in Wellington New Zealand

and Lelley (2003) referred to a hull-less 'oil pumpkin' cultivar SZG1 from France that was used along with two Austrian cultivars in a histology study of the hull-less character. The absence of definitive data relevant to seed type or the country of origin makes substantiation of other 'oil pumpkin' varieties difficult in the context of the current study. This is probably not important because as already stated, peer review articles routinely acknowledge that all hull-less phenotypes are likely to have descended directly from the Austrian mutation.

Despite evidence of plant breeding programs relating to pumpkin cultivars with the hull-less seed trait, much of the European industry is still reliant on the collection of seed from self-pollinated lines that have been handed down from generation to generation. Teppner (2004, p. 297) reported that many farmers rely on, and 'have more confidence in their own traditional landraces'. This contention has been well supported by anecdotal evidence developed during the course of this study. These traditional varieties have been collected and retained by individual farmers. They are not hybrid cultivars. In the Styrian region many farmers have been conducting their own selections for over 100 years. These selections have been based on visual characteristics such as seed yield, seed size, seed colour and oil yield (Winkler 2000).

The use of hull-less pumpkin seed for oil production remains the largest industry related to pumpkin seed use (Loy 2004). The hull-less seeds of 'oil pumpkins', whilst once almost exclusively used for oil production are becoming more widely used in pharmaceutical products, the snack seed market, baked products and confectionary items.

...Breeding of semi-bush pumpkin cultivars with the hull-less seed trait is still continuing at the University of New Hampshire. These varieties are being bred predominantly to produce roasted seed for the snack trade as there is really not a large market for pumpkin seed oil in North America (⁴J. Brent Loy pers. comm., 2 February 2011).

It is understandable that research work utilising the hull-less trait is occurring because de-hulling necessitates an additional processing operation.

Hulled Pumpkin Seed

There are many literature precedents where cucurbit seed has been cited as a source of protein and oil. The same articles usually do not specify the type of seed used. There are many pumpkin seed products available in Australian supermarkets and health food stores. It has been difficult to determine the actual *Cucurbita* species these are derived from. A cursory internet search quickly confirms that pumpkin seed is a commodity that is traded extensively across the world. Companies in countries such as China, India, Cameroon, Turkey, Bulgaria and Romania advertise seed widely. Neither advertising detail nor direct approaches could shed light on the cultivars used let alone the actual *Cucurbita* spp. For example Chinese and Cameroon seed was simply advertised with names such as White Pumpkin, Snow White or Shine Skin. Seed originating from the Ukraine and other Eastern European countries were advertised with names such as Lady Nail, Snow White and Grey Volga. In the United States, marketing companies advertised pumpkin seed with names such as Eastern European, Long Pie, Howden, Baby Pam and New England Pie. All of these pumpkin seed lines are likely to be hulled seed types originating from various cultivars of *C. pepo* and *C. maxima* (⁵J. Brent Loy pers. comm., 14 September 2010).

Currently, most seed imported into the United States is derived from hulled seed lines of *C. pepo* originating from China and *C. argyrosperma* originating from Central America (Loy 2004). In the

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United States, the State of Oregon is a recognised production area of pumpkin seed (Loy 2004). This seed is predominately derived from *C. maxima* and is a large white hulled seed type. When hulled pumpkin seed cultivars are grown for the confectionery market in the United States, the seed processor determines the variety to be used (Oregon State University 2004). One commonly used cultivar for this seed processing is Golden Delicious, a *C. maxima* cultivar (Loy 2004). This cultivar is normally grown for its flesh but if it is produced specifically for seed, plant populations are increased in an effort to produce more seed per designated area (Oregon State University 2004).

Planting and Growing Pumpkins for Edible Seed Production

Agronomics

The current project had an objective to investigate industry knowledge on cucurbit production and assess limitations that may specifically relate to North East Victoria. The availability of detail specific to edible pumpkin seed production is scarce, even from recognised international production areas. For Australian conditions, published literature relating to seed production is also difficult to source. It is likely that commercial in-confidence information is held by Australian seed companies who produce seed for commercial pumpkin flesh producers. Therefore, a very basic summation of agronomy factors relating to pumpkin seed production is included in this report. Specific agronomic attributes that relate to maximising seed yield and quality may emerge as production expands in Australia.

In one of the few published articles which had discussion relating to agronomic aspects of edible pumpkin seed production, Bavec et al. (2007) utilised trial work with organically grown ‘oil pumpkin’ cultivars to highlight key production factors. Whilst the authors did not acknowledge any agronomic practice that would seem out of place in a pumpkin flesh enterprise, they did place significant focus on the necessity for adequate crop rotation and the maintenance of a high soil organic matter levels, and soil pH’s greater than 6.0. Articles published by European Seed Companies mention adequate nitrogen as being a critical aspect of growing ‘oil pumpkin’ cultivars for seed production. Berenji (2000) singled out boron when he reported on ‘oil pumpkin’ trials in Serbia. He indicated that soil boron levels can impact on seed set and seed fill in ‘oil pumpkin’ cultivars. Factors such as pH, nitrogen, boron and general management programs could just as easily relate to pumpkin flesh production.

In the short term, practices utilised in conventional pumpkin production are the most reliable method to extrapolate best practice methods for seed production. It is likely that agronomic requirements necessary for high quality seed production will be similar but not identical to those used for pumpkin flesh production. Cultivars utilised for flesh production are ubiquitous crops in many parts of Australia. Historically, pumpkins have been grown in all Australian states. Generic production guidelines for various pumpkin types are relatively consistent across several Australian states. Jarrahdale, Japanese and Butternut pumpkins are routinely mentioned in Australian pumpkin production guides. Jarrahdale is a cultivar of *C. maxima* whilst Japanese and Butternut pumpkin are types of *C. moschata*. Australian literature is quite consistent in stating that pumpkins can grow on a broad range of free draining soil types.

In Victorian conditions ‘well-drained soils that warm rapidly in Spring’, have adequate organic matter, and a capacity to retain moisture are ideal for pumpkin production (Dimsey 1994, p. 1). Japanese pumpkin is a collective term used for cultivars of *C. moschata* originally grown in Japan (Morgan and Midmore 2003). Top and Ashcroft (2000) completed a Victorian production manual for Japanese pumpkins. They discussed a preferred pH range of 5.8–6.8 but acknowledged that Japanese pumpkins will even tolerate a slightly broader pH range than this. Napier (2009, p. 2) in a pumpkin production guide, prepared for New South Wales situations, also stated that whilst soil pH’s between 6.0–6.5 are preferred, pumpkins will ‘tolerate both slightly acid or alkaline soils’.

Pumpkins are sensitive to low temperatures. Frost events will be lethal to plants at all growth stages. Drought or extended dry conditions can compromise germination and growth. 'Temperatures of 20°C to 35 °C are ideal for maximum production' (Napier 2009, p. 2). Pumpkins are quite hardy but prolonged moisture shortages will influence vegetative, fruit and seed yield. Therefore most commercial pumpkin production in Australia will require irrigation. 'Pumpkin seed needs a minimum soil temperature of 15 °C to germinate' (Dimsey 1994, p. 1). This would be a critical indicator for seeding particularly in cooler climates. Napier (2009) used a minimum soil temperature of 16 °C as a guide for seeding in the Murrumbidgee Irrigation area but warned that with some cultivars the risk of seeding too late can lead to yield and quality losses if the season is not sufficiently long enough to mature the fruit. 'Pumpkins can take about 13 to 25 weeks from planting to maturity, depending on variety and climate' (Napier 2009, p. 3).

Thorough preparation of an adequate seedbed is essential. The equipment and the number of machinery passes required to prepare a weed free seedbed will depend on soil type and localised soil conditions. In Australia pumpkin seed is often sown into raised beds. The use of this production technique would need to be assessed according to soil type and perhaps harvest methods if a pumpkin seed venture was contemplated. Top and Ashcroft (2000) discussed a seeding depth of 3–4 cm (for Japanese pumpkins) but acknowledged that the actual sowing depth will be dependent on soil conditions. Saatucht Gleisdorf (2010) list a planting seed depth of 2–4 cm for 'oil pumpkin' cultivars seeded in Central European conditions.

Many of the general nutritional requirements necessary for pumpkin flesh production will likely match those required for the optimisation of seed production. Crop nutrition will depend on many factors. These include existing soil condition, planting density, likely yield and the availability of a current soil test. Appropriate nutrition programs will have a significant effect on crop growth and fruit or seed yield. Napier (2009) warned that over use of fertiliser can lead to excessive foliage growth at the expense of fruit yield. Nitrogen is a nutrient that requires careful management. Various publications refer to split applications of nitrogen as being an industry norm. This could imply some nitrogen at planting with the balance in successive applications following germination, but prior to rapid vine development. Nitrogen is routinely singled out as a nutrient where excesses can lead to negative impacts on fruit yield. Napier (2009, p. 3) indicated that 'female flowers can fail to set if there are excessive levels of nitrogen early in the growing period'. Top and Ashcroft (2000) discussed a nitrogen range of 120–180 kg/ha for Japanese pumpkins in Victoria. An actual level would need to be determined for a particular locality based on paddock history and localised soil conditions. Leaf analysis used according to sampling guidelines may also be an additional tool used to guide whether a base nutrition program requires maintenance.

High organic matter levels are routinely cited as a key determinant for high yielding pumpkin production. Dimsey (1994) acknowledged this by suggesting that chicken manure may need to be applied in situations where pumpkin crops are sown without a preceding cover crop. 'Animal manures can be used for growing pumpkins and should be incorporated at least four to six weeks prior to sowing' (Napier 2009, p. 4). Animal manures can be applied at rates of approximately 5 tonnes/ha (Napier 2009). In 'oil pumpkin' production areas in Central Europe many producers utilise organic production philosophies and use this aspect as a marketing tool. Bavec et al. (2007, p. 186) indicated that many of these farmers are utilising '25,000 – 45,000 kg/ha of stable manure' prior to planting an 'oil pumpkin' cultivar.

Pollination

Pollination is a critical consideration for pumpkin production. There are both male and female flowers on the same plant. Some management practices and environmental factors such as temperature, light, humidity and soil moisture can influence the number of female to male flowers (Napier 2009). To improve fruit setting, beehives need to be sited in or adjacent to the crop to coincide with the commencement of flowering. Authors have different guidelines for hive numbers. The actual

requirement will depend on the species being grown and the presence of wild pollinators. Dimsey (1994, p.1) discussed ‘five or six beehives per hectare’ in a Victorian article whilst Napier (2009, p. 5) referred to ‘two to three beehives per hectare’ in one New South Wales production area. Temperature extremes and windy weather can influence pollination. Death or low production of pollen can result in poor fruit set or influence the likelihood of fruit abortion (Napier 2009). Pesticide use is an important consideration in conjunction with the timing of beehive placement. Cross-pollination can take place between different *Cucurbita* species but this is unlikely to affect the crop yield (Napier 2009). Seed resulting in instances where cross-pollination has occurred should not be saved for future planting because it will be genetically different to the parents (Napier 2009).

Irrigation

A detailed synopsis of the irrigation requirements for maximising pumpkin production was not conducted in the current study. The type of irrigation infrastructure and the total water requirements for Australian production will depend on local conditions. Water requirements will be greatest during germination through to fruit set. Late in the season over irrigating is more likely to contribute to fruit rots as the pumpkin fruits ripen. Strategic timing of irrigation is likely to be important in instances where foliar diseases such as mildews are likely to be a problem. When referring to Japanese pumpkins, Top and Ashcroft (2000, p. 12) stated that ‘overhead irrigation should be applied in the morning, so that plant foliage is dry by the evening’. This practice would help reduce the risk of spreading diseases such as powdery mildew. Suffice to say, regardless of the geographic production area, maximum production will be dependent on careful monitoring of the soil moisture status and the management of irrigation scheduling.

Plant Spacing

Pumpkin plantings will normally be direct seeded. This is likely to be the most cost effective method of crop establishment but necessitates specialist seeding equipment and optimum germination conditions to ensure adequate plant population is attained. Bavec et al. (2007, p. 186) reported that in Central European ‘oil pumpkin’ production areas ‘higher yields and more reliable production’ is obtained ‘through the use of transplants’. This technique will be a more expensive method of crop establishment. Regardless of whether a crop is derived from direct seeding or from transplants, plant density will be an important aspect of crop management. Plant density will affect fruit size, fruit yield, the number of fruit per plant (Napier 2009) and the seed yield (Augustinović et al. 2006). The use of raised beds will also influence planting density if that technique is utilised.

Planting density will also depend on the growth habit of the pumpkin cultivar sown. Cultivars grown for their edible seed may be vinous, bush or semi-bush types.

...Unpublished research conducted at the University of New Hampshire has assessed the influence of plant spacing and nitrogen fertility on plant development and seed yield of semi-bush cultivars. With current knowledge the preferred spacing of the semi-bush seed producing cultivars is 200 cm (between rows) x 30 cm (between plants) (⁶J. Brent Loy pers. comm., 2 February 2011).

Most ‘oil pumpkin’ production occurring in Central Europe is based on vinous cultivars. Bavec et al. (2007) discussed plant populations of 1.0–1.5 plants per square metre for vinous ‘oil pumpkin’ cultivars grown in Slovenia. They indicated that modern row cropping machinery and inter-row cultivation techniques are leading to more structured seeding configurations; row widths of 1.4–2.1 metres are commonly used to optimise seed yield in ‘oil pumpkin’ cultivars. To achieve the desired plant population this necessitates 3–4 kg seeds/ha or 6–7 kg seeds/ha depending on the seeding

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method (Bavec et al. 2007). It is likely that precision seeding equipment would necessitate lower seed requirements. A planting guide published by Saatzucht Gleisdorf (2010) in Austria discussed various 'oil pumpkin' seeding configurations which ranged from 1.0–1.4 metres (between rows) and 0.53–0.77 metres (between plants). This again equates to plant densities in the range of 1.0–1.4 plants per square metre or in other words 10,000 to 14,000 viable plants per hectare. Saatzucht Gleisdorf (2010) use 18,000 seeds per hectare as a guide for seed requirements. Augustinović et al. (2006) utilised a Gleisdorf vinous Austrian 'oil pumpkin' cultivar to conduct replicated plant spacing trials over two seasons in Croatia. The authors acknowledged a lack of reliable oil cultivar plant spacing data in their region. They assessed five spacing configurations which ranged from 1.0–1.4 metres (between rows) and 0.3–1.0 metres (between plants). This led to plant populations of 10,000 to 23,810 plants per hectare. The highest seed yield per hectare in both years was obtained at a 1.4 metre (between rows) and 0.3 metres (between plants) spacing but the difference was statistically significant only in one season (Augustinović et al. 2006).

Production locations in Australia

Based on current knowledge it is difficult to nominate preferred locations for pumpkin seed production in Australia. In the short term, conventional pumpkin flesh production sites are probably the best reliable guide. Morgan and Midmore (2003), for example, conducted a study on Kabocha and Japanese Pumpkin Production in Australia. Their trials and broader study confirmed that these pumpkins can be grown in all Australian states to give year round supply. They acknowledged that pumpkin type (genetics), season, maturity, and location can affect various aspects of yield and quality. This current study cannot definitively predict preferred geographical production areas for cultivars to be utilised for edible seed production. The Morgan and Midmore (2003) study and the historical production of other pumpkin types suggest that Australia would likely have many suitable locations for growing cultivars suited to seed production. Localised climatic and seasonal constraints, soil condition, and dedicated specific infrastructure would all influence a preferred production location. Various authors have reported that the particular climatic niche of traditional production areas of 'oil pumpkins' in Central Europe contributes to quality aspects of the oil produced. This assessment will need to be tested for Australian conditions. Potential production areas may also be limited by the likelihood of insect and disease pressure. In the United States seed pumpkin cultivars are better suited to dry climate locations due to potential problems with bacterial and fungal diseases (⁷J. Brent Loy pers. comm., 2 February 2011).

Pest and disease pressure associated with any commercial pumpkin seed production will depend on the location. There are a range of registered crop protection agents that would be suitable for most likely pest and disease situations in Australian conditions. Proposed pumpkin production, particularly in new production areas, would need to be accompanied by a thorough investigation of likely pest and disease scenarios as well as hypothetical strategies to deal with each problem.

Quality Assurance

Food safety standards are another issue that require investigation or clarification before an ongoing, quality assured pumpkin seed industry of scale could develop in Australia. The Australian Pesticides and Veterinary Medicines Authority (APVMA) establish Maximum Residue Limits (MRLs) to cover residues arising from approved uses of pesticides in Australia. These MRLs are formally declared into Standard 1.4.2 under processes agreed with Food Standards Australia New Zealand (FSANZ 2011). The APVMA undertakes its commodity description utilising the codex classification of foods and feeds which has been developed to assist in commodity classification for MRL development. There is no separate entry in the codex classification for pumpkin seed (FAO 1993). This would imply that pumpkin seed would currently be assessed under MRLs set by the APVMA Standard applicable to

whole pumpkin. Therefore the current APVMA Standard would theoretically apply to pumpkin seed and pumpkin seed oil produced from a pumpkin crop that has been treated with approved pesticides. If there were data available that showed that particular pesticides concentrated into pumpkin seed or oil the APVMA may consider establishing separate MRLs for pumpkin seed and/or oil.

There could in fact be situations where past pesticide use may affect pumpkin seed suitability from a quality assurance perspective. This is based on evidence in some international peer review literature where past pesticide use has impacted on the production of edible pumpkin seed. For example, the fungicide hexachlorobenzene and organochlorine insecticides have been detected in agricultural soils and in the seeds of 'oil pumpkins' grown on some Central European fields (Mandl and Lindner 1999). This aspect may require investigation or clarification as it potentially could relate to some production situations in Australia.

Organic Production of Pumpkin Seed

Pumpkin seed production in Central Europe is closely linked to traditional crop management and processing techniques. There is evidence that a proportion of the Central European 'oil pumpkin' seed production is marketed as organic. In traditional production areas 'oil pumpkin' seed produced without a reliance on inorganic crop protection agents or fertiliser products is seen as a marketing tool to complement the reputed medicinal benefits of the commodity. There is a strong movement in the traditional production areas to market organic pumpkin seed. Bavec et al. (2007) reported organic production of 'oil pumpkins' routinely commences with manure, rather than inorganic fertilisers, in the autumn preceding seeding. Many 'oil pumpkin' enterprises in Central Europe are conducted in conjunction with mixed farming enterprises and therefore manure is readily and cheaply available. Rotations of four to five years between pumpkin crops and a significant focus on green manure crops are encouraged (Bavec et al. 2007).

Organic food production is a heavily regulated industry. Many countries require producers to obtain specific certification in order to market food products as organic. It is important to define organic products according to the certification requirements in the country of origin. For example there may be different certification requirements in different countries. These differences could relate to permissible crop nutrition and crop protection programs. There may be other requirements too. For example, in the instance of pumpkins there may be a necessity to implement a rotation management plan to ensure that members of the same family are not continuously planted in a defined production area. Continuous cropping of related species is often difficult to manage from a disease control perspective in conventional production systems but becomes even more problematic in an organic culture system. There may be instances where potential Australian producers of pumpkin seed may want to grow cultivars according to organic principles. This is because oil products and other specialist pumpkin seed products may be sold through outlets where customers have a preference for organically grown produce. Such production would need to be assessed under Australian conditions.

Harvest of Pumpkin Seed

Timing

A critical aspect of maximising pumpkin seed yield will be the timing of harvest. Fruit maturity will be dependent on factors such as cultivar, management, geographic location, and prevailing seasonal conditions. For conventional pumpkin flesh production the fruit are allowed to fully mature in the field. Napier (2009, p. 7) reported that pumpkins are ready for harvest when the fruit stalk becomes 'cracked and corky' and the fruit skin colour fades. Bavec et al. (2007) also reported that full fruit maturity is necessary if the oil content of traditional Slovenian 'oil pumpkin' cultivars is to be maximised. In Slovenian cultivars this maturity is indicated by a general yellowing of the pumpkin skin although the shaded side of the fruit may still have some green stripes evident (Bavec et al. 2007). Pumpkin seed to be utilised for a snack seed or processing market must have sufficient time in

the field to fully expand and fill. Therefore optimising harvest time would be a critical aspect of both yield and quality of pumpkin seed.

When pumpkins are grown for flesh production any damage that can initiate rots during storage and transport must be minimised. Management should include careful handling of harvested fruit and consideration of the time that pumpkins sit in the field after being cut from the vine. Prevailing climatic conditions may also affect handling practices. 'In bright sunshine fruit temperature rises quickly and sunburn can occur if fruits are left fully exposed for more than 1–2 hours' (Top and Ashcroft 2000, p. 17). However, in cooler Central European 'oil pumpkin' production areas it is apparently common for pumpkins to sit in the field for several days after they have been removed from the vine. In seed production instances, once pumpkins are removed from the vines prevailing climatic conditions need to be monitored to ensure no damage that could influence seed quality occurs to the fruit. Lelley, Loy and Murkovic (2009) reported that fruit rots can cause off-flavours in hull-less pumpkin seed if affected fruit is harvested and mixed with sound fruit. Specialised harvesters can be used to pick up pumpkins and separate the seed from the flesh in the field. Pumpkins need to be windrowed into rows to enable these harvesters to operate efficiently.

It is once again important to acknowledge the potential differences in pumpkin cultivars. Harvest and storage practices and requirements that relate to conventional pumpkin flesh cultivars are likely to be quite different to the techniques utilised for cultivars harvested for their seed. Each factor will require assessment and fine tuning as a dedicated pumpkin seed industry develops in Australia.

Aspects of Pumpkin Seed Yield

Lelley, Loy and Murkovic (2009) speculated that pumpkin seed yields must increase if the seed is to remain competitive with other products. Loy (2004) conducted a review on the physiological, morphological and ecological aspects of crop yield for the genus *Cucurbita*. In this study he included components that related to seed yield because of the increasing use of *Cucurbita* seed for oil production, snack seed use and pharmaceutical purposes. Loy (2004) gave a detailed summary of the relationship of seed yields relative to total fruit weights. Much of the pumpkin seed currently on world markets is a by-product of flesh production and therefore seed yield may not be a primary consideration. In situations where pumpkins are specifically grown for seed production, maximising the yield will be critical to industry sustainability. In the published review Loy (2004) discussed three useful measures that can be used for evaluating seed production efficiency in both open pollinated and hybrid cultivars. These were a *seed index*, a *seed yield index* and a *seed efficiency index*. The *seed index* is seed dry weight divided by total fruit dry weight whilst the *seed yield index* is a seed dry weight per kilogram of fresh fruit weight (Loy 2004). The *seed index* and *seed yield index* had been used for some time but Loy (2004) proposed a third measure the *seed efficiency index*. This is a ratio of seed energy content to total fruit energy content.

Loy (2004) speculated that large seed size, which is a feature of the traditional 'oil pumpkin' cultivars of Central Europe, has probably been a conscious selection criteria used because large seed favours easier seed extraction. Historically, seed extraction was a job done by hand, so large seed size would have been a useful characteristic. Loy (2004) reported that although large pumpkins usually produce a higher dry weight of seed than smaller pumpkins, the seed yield relative to fruit weight are lower. He used data from previous studies he had been involved with to support this contention. Older cultivars of 'oil pumpkin' tend to produce quite large fruit. For example, Winkler (2000) reported that fruit of Gleisdorfer Ölkürbis, an 'oil pumpkin' cultivar widely used in Central Europe, has a fresh weight ranging from 3–7 kilograms. She reported that older cultivars of Styrian 'oil pumpkins' often have *seed yield indexes* as low as 1.5 percent. This equates to 15 grams of dry seed per kilogram of fruit fresh weight. Loy (2004), on the other hand, summarised a number of studies that showed some high yielding hybrid breeding selections had *seed yield indexes* of 5.0 percent and greater. This equates to 50 grams of dry seed per kilogram of fruit fresh weight.

Investigations into high seed yielding cultivars commenced at the University of New Hampshire in the 1970's. That program has predominantly led to the development of bush-type cultivars. These cultivars tend to produce relatively small fruit ranging from 0.5–1.5 kilograms (Loy 1990). Obtaining large seed size in small fruited cultivars is difficult (Loy 2004). The 'oil pumpkin' breeding program conducted at Saatzucht Gleisdorf has also developed some bush-type cultivars which have short vines, small fruit and more fruit per plant (Winkler 2000). The bush characteristic was incorporated into the breeding program in order to increase seed yields but also to reduce variability in fruit maturation time.

Pumpkin Seed Yields

Economic production of edible pumpkin seed in Australia would be linked to a yield-price relationship. Pumpkin seed stores well and is easily transportable so import pressure will be significant and ongoing. Inevitably Australian producers would find it difficult to compete on price with international markets. A potential Australian pumpkin seed production industry would depend on field efficiencies through agronomic excellence, mechanisation and demand for a local product produced with transparent quality assurance protocols.

The expected seed yield from cultivars grown in the traditional 'oil pumpkin' production areas of Central Europe ranges from 500–800 kg dry seeds/ha but occasionally is as high as 1,200 kg/ha (Bavec et al. 2007). Approximately 2.5 kilograms of dried seed is required to produce one litre of oil (GAIN 2004). Plant breeding conducted at the University of New Hampshire has utilised the hull-less seed trait and focused on seed yield. There has also been effort in this program to utilise the bush growth habit and manage plant spacing to improve seed yields. The bush growth habit has contributed to high density plantings that produce fast leaf canopy development and more uniform fruit maturation. The pumpkin breeding program based at the University of New Hampshire has developed several breeding lines and cultivars with both the hull-less seed and the bush growth habit traits (Lelley, Loy and Murkovic (2009). Some of the beneficial attributes of the bush growth habit were recognised in Europe by early 'oil pumpkin' breeders such as Erich von Tschermak-Seysenegg.

Loy (2004) summarised the work of several authors and reported that the seed coat of hull-less pumpkin cultivars comprise only 7 to 12 percent of the total seed weight, whilst the seed coat of hulled cultivars of *C. pepo* and *C. maxima* comprise at least 20 percent of the total seed weight. Cultivars developed in the University of New Hampshire program and used for seed production have predominantly been hull-less seed types. They have a higher yield potential than the Austrian hull-less 'oil pumpkin' lines.

Yields of 1500–2000 kg/ha of dried seed are possible with the hull-less seeded semi-bush cultivars as compared to 600–900 kg/ha of dried seed common with the vinous Austrian 'oil pumpkin' cultivars. We think these yields are easily possible based on our plot research and on yields obtained from a one hectare plot in Northern California several years ago (⁸J. Brent Loy pers. comm., 2 February 2011).

Economic production of edible pumpkin seed in the United States is also very dependent on the yield-price relationship. In a number of publications J Brent Loy has speculated that high seed yields would be necessary to support commercialisation of a United States based hull-less pumpkin seed enterprise targeting the snack seed trade. This is certainly the case in Australia too. The definition of high seed yields will be the key determinant.

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Processing of Pumpkin Seed

Early Stages

Pumpkin seed that will be used directly as a snack product or stored for further processing will require separation from the pumpkin flesh. The seed will also need to be cleaned or washed. In some areas of the world either hulled or hull-less pumpkin seed is produced on small acreage farms where hand harvest of pumpkins and hand removal and washing of seed is conducted. This approach would not be satisfactory if a field production enterprise of significant scale is contemplated. In Central Europe the harvest and cleaning of hull-less 'oil pumpkin' seed production is highly mechanised. This is also the case in production areas of the United States where pumpkin seed is destined for the snack seed market. In some situations before harvested pumpkin seed is cleaned/washed it may be left to sit in bins for a period of time. Martin (1984) reported that cucurbit seed can often be more readily separated from the remnants of the stringy pumpkin flesh pulp following a light fermentation of the harvested seed for 24–72 hours. This process would potentially aid the seed cleaning process following machine harvest of seed and can occur as the harvested seed sits in bins or containers. Non peer review articles emanating from 'oil pumpkin' production areas in Central Europe routinely discuss the difficulties in washing freshly harvested pumpkin seed due to the stringy pumpkin flesh remnants that stick to the seed.

Following the harvest and washing processes, pumpkin seed must be dried to ensure it can be stored with the correct moisture content. After drying, the seed may also be brushed to remove seed coat membranes. In small scale production operations the drying process may be quite rudimentary. Seed can be dried passively without specialised equipment. In larger commercial production operations the drying process will require specialised facilities. Washed pumpkin seed is dried at 40 to 60 °C until it reaches a moisture content of 8–10 percent (Bavec et al. 2007). Stored seed requires careful moisture monitoring to ensure moulds do not develop and the seed remains nutritionally and chemically sound.

Whether pumpkin seed is a hulled or hull-less type, production of significant scale will require a degree of mechanisation. It may not be necessary for growers to be responsible for all aspects of the harvest, seed washing and seed drying processes. Some operations could be conducted on a contract or co-operative basis. There are certainly precedents in Central European 'oil pumpkin' production areas where farmers do not own specialised equipment. Some producers merely grow the crop and rely on contractors for other operations such as harvest, washing and drying. Alternatively, some farmers simply send wet harvested seed directly to processors who conduct all other washing and drying requirements.

Beyond the farm gate, infrastructure requirements to process pumpkin seed could potentially be quite significant. This will be dependent on the extent of additional processing that is required. Mechanisation to accommodate this would have economies of scale implications because a minimum volume of seed would be necessary to warrant investment. Potential investors would then need to consider if dedicated equipment could be utilised for other purposes. For example, hulled pumpkin seed can be hulled, sorted and sized using specialised equipment. Some markets may also require seed to be colour sorted. Each process would add an extra dimension to any capitalisation. A significant advantage of hull-less seed cultivars is that hulling mechanisation is not required. Depending on the end use, seed from hull-less cultivars would likely require sizing and possibly colour sorting. Pumpkin seed can be processed in various ways. It can be salted and roasted, or treated with various spices or flavourings in order to be attractive to particular markets. Pumpkin seed may even be sold as a sweet. This would require a coating process. Infrastructure to facilitate this type of additional processing may therefore need to be considered.

Oil Pressing

Oil extraction from pumpkin seed also requires dedicated equipment. Pumpkin seed can be pressed as required because pumpkin seed stores well. Oil can be manufactured from both hulled and hull-less pumpkin seed cultivars. Oil derived from the hull-less pumpkin seed cultivars is the basis of the significant industry in Central Europe. The thick oil produced from the hull-less cultivars tends to be a dark green to even a red colour. Bavec et al. (2007) reported that Central European hull-less oil pumpkin seed is either hot pressed or cold pressed. Pumpkin oil extraction is a significant industry in Central Europe. An indication of the industry scale can be gauged by the number of mills. Thirty five oil mills as well as at least 2,000 farmers producing 'oil pumpkins' joined forces to launch a regional brand 'Styrian pumpkin seed oil' (GAIN 2004). Many of the specific processes involved with pumpkin seed milling and oil extraction are closely held secrets because they involve practices that have been developed, refined and handed down over many years.

Bavec et al. (2007) reported that in Central European production areas, whilst hot pressing is the traditional method for producing oil from pumpkin seeds, cold pressing is also used. Cold pressing is based purely on the mechanical pressing of dry seeds without seed roasting or other treatments (Bavec et al. 2007). A quite detailed presentation on cold pressing of 'oil pumpkin' seed was given at the 1999 Oil Pumpkin Conference. In this presentation Artyomenko (2000) indicated his Russian based company used a cold press process because the oil produced was destined for the pharmaceutical trade. Oil yields related to cold pressing are historically lower but the oil is regarded as of a higher quality than the hot pressed counterpart. The traditional hot press process for 'oil pumpkin' seed includes milling the seed through a stone mill, blending the milled pumpkin seed with water and salt, and then roasting the seed (in pans) to 100–130 °C (Bavec et al. 2007). Even though this pressing process is referred to as hot it is still comparatively cool compared to many other oilseed crops. After the roasting or cooking process the hot material is loaded directly into a press so the oil can be extracted. Much of the commercial in-confidence detail that relates to hot pressing of pumpkin seed revolves around the precise temperatures and timeframes that are used for the roasting process. The ratio of the salt and water used for the blending process is also a point of difference between various processors. These variables can reputedly influence flavor, aroma and even chemistry of the pumpkin seed oil. Bavec et al. (2007) referred to studies conducted by several other authors who had followed the fate of volatile and non-volatile compounds in pumpkin seed roasted at different temperatures and the subsequent impact this had on oil aroma and chemistry. At the completion of seed pressing the oil is left to stand for a period of time. This allows any fine seed particles to settle and enables the pure oil to be decanted.

Marketing Issues for Pumpkin Seed

Uses

Pumpkin seed, and products derived from it, are consumed throughout the world. Large quantities of seed originate from China, Central America and some African countries. Often, the pumpkin seed available is simply a by-product of pumpkin flesh production. There are situations where crops are grown specifically for seed harvest. Pumpkin seed is used in trail mixes or sold as snack food (Loy 2004). Trail mixes normally include various nuts, seeds, dried fruit and perhaps even sweets. A variety of trail mixes can be purchased in Australian supermarkets. Pumpkin seed can also be used as an ingredient in breakfast cereals and specialty breads. In the United States pumpkin seed is used extensively as snack food. This seed may be roasted and treated with salt or spices. In Central Europe, pumpkin seed is used as a snack food too but it is pumpkin seed oils, derived from hull-less seed cultivars, that are widely sought after. Bavec et al. (2007) discussed the emerging niche market opportunities for hull-less pumpkin seed. These included edible oils, natural and roasted seeds, and supplements for seed bars.

Pumpkin seed oil is used with salads, soups and pasta. It can be used as a salad dressing and is sometimes mixed with olive oil, honey or vinegar. As already noted the oil derived from hull-less seed cultivars is a dark colour and usually has a green or perhaps even a red tinge. Lelley, Loy and Murkovic (2009) reported that the dark colour originates from a green substance referred to as protochlorophyll which occurs in the innermost layer of the seed chlorenchyma. 'These pigments are extracted into the oil providing its typical, dark green colour' (Lelley, Loy and Murkovic 2009, p. 473). These substances are known to absorb light and initiate lipid oxidation. It is for this reason that dark pumpkin seed oil should be stored in the dark. Due to its colour and the formation of foam, the oil cannot be used for cooking (Murkovic et al. 1996). The oil of the Chinese hull-less *C. moschata* cultivar Zhou is likely to be more resistant to light initiated oxidation because the seed does not contain the protochlorophylls (Lelley, Loy and Murkovic 2009). Hulled pumpkin seed can also be used to produce oil too although it tends to be a clear or straw colour.

Seed meal, which is a byproduct of pumpkin seed oil production, is another product that can be derived from pumpkin seed. Pumpkin seed meal is often referred to as defatted pumpkin flour. Its protein content can be in excess of 60 percent (Lazos 1992). This product can be used as a breadcrumb replacement or to flavour food products such as biscuits. It is widely sought after in Central Europe as a high protein stock feed.

Packaged pumpkin seed or pepitas are also readily available in Australian supermarkets and health food shops. Most of this seed is normally pale green and 5–10 mm in length and probably has originated from hulled seed cultivars. Occasionally, a larger, darker green seed is also available in Australian stores. This seed has possibly been derived from hull-less pumpkin cultivars although only a specialist would be able to definitively confirm this. Neither seed type nor the country of origin is specified on packaging for most pumpkin seed or pumpkin seed products available in Australia. On world markets the price of all pumpkin seed is highly variable. Anecdotal evidence suggests hull-less pumpkin seed originating from traditional Central European production areas has historically commanded a higher price but this could not be accurately verified in the current study.

Health Traits of Pumpkin Seed

The main nutritionally relevant components of pumpkin seed are protein and oil. Loy (2004) summarised previous studies and reported that pumpkin seed is a high energy food source because the dried seed is 40–50 percent lipids and 30–37 percent protein. The major fatty acids in pumpkin seed include palmitic acid (C 16:0), stearic acid (C 18:0), oleic acid (C 18:1), and linoleic acid (C 18:2) of which linoleic acid is the most prominent, followed by oleic acid and palmitic acid (Lelley, Loy and Murkovic 2009). Relatively high proportions of the unsaturated fatty acids linoleic acid and oleic acid contribute to the seed's nutritional value. Albumins and globulins constitute approximately 60 percent of the crude protein content of pumpkin seed (Lelley, Loy and Murkovic 2009). Vitamin E is a generic term used to describe tocopherols and tocotrienols. These are prominent in pumpkin seed. The tocopherol content present in pumpkin seed is dominated by concentrations of γ -tocopherol 5–10 times higher than the concentration of α -tocopherol whilst significant amounts of α - and γ -tocotrienols are also present (Lelley, Loy and Murkovic 2009).

The nutritional attributes of pumpkin seed are of particular interest to breeders of hull-less 'oil pumpkin' cultivars. In addition to normal selection characteristics such as seed yield and oil content, a significant focus of 'oil pumpkin' breeding work at Saatucht Gleisdorf in Austria is unsaturated fatty acid and tocopherol content (Winkler 2000). She contended that 'oil pumpkin' cultivars do have variability in these components. Murkovic et al. (1996) had also observed high variability in the oil content of 'oil pumpkin' cultivars. They contended this broad genetic diversity could be used in breeding programs to increase oil productivity.

Climate may influence some of the nutritional aspects of pumpkin seed. The traditional European 'oil pumpkin' production areas routinely link oil quality to climate. Winkler (2000) acknowledged that the climatic characteristics of the traditional 'oil pumpkin' production areas of Central Europe could positively influence the oil content and the linoleic acid content of seed. Data presented by Winkler (2000) indicated that higher temperatures can negatively affect both these parameters. Berenji (2000) also cited seed chemical composition as a selection criterion in the Serbian 'oil pumpkin' breeding program at Novi Sad. Murkovic et al. (1996) in an earlier study noted that whilst fatty acid content is clearly influenced by climate during seed ripening, tocopherols are less influenced.

Pumpkin seed contains phytosterols that are dominated by $\Delta 7$ -sterols (Lelley, Loy and Murkovic 2009). Once pumpkin seed oil has been produced its phytosterol composition can be tested to detect if the oil has been contaminated or deliberately adulterated by other plant oils. Pumpkin seed oil has uniquely lower levels of $\Delta 5$ -sterols than other plant oils (Lelley, Loy and Murkovic 2009). Carotenoids, especially lutein, are found in pumpkin flesh but are also present in the seed (Lelley, Loy and Murkovic 2009). Lignans are another group of physiologically active substances found in pumpkin seed (Lelley, Loy and Murkovic 2009). Pumpkin seed is also a good source of the elements potassium, phosphorous and iron.

Oil pumpkin seed is increasingly used in pharmaceutical products. Testimonials from users of pumpkin seed products are often used as a marketing tool to laud medicinal benefits. These and other health proponents claim that pumpkin seed products can be beneficial for the treatment and alleviation of several medical disorders. Claims alone are not sufficient to promote the merits of the products. Health messages endorsed by science will be a more powerful tool to build up a market demand for products such as pumpkin seed and pumpkin seed oil. The attributes of pumpkin seed and products derived from it are the basis of many studies. Several peer reviewed articles reporting on pharmaceutical benefits of compounds in pumpkin seed products are now available. Lelley, Loy and Murkovic (2009) presented extensive detail on some of the nutritional and pharmaceutical attributes of pumpkin seeds and pumpkin seed oil.

Scale of World Pumpkin Seed Production

It has been difficult to put scale on the extent of field production of pumpkin cultivars that are grown specifically for the harvest of edible seed. In part this is due to statistics; pumpkin seed is often categorised as 'seed general' or 'oilseed' in import/export data. Therefore, pumpkin seed trade and usage data often becomes lost in broader statistics. Another factor is that pumpkin seed available in the market place is often a by-product of pumpkin flesh production. So, once again seed production data can become lost in a broader vegetable category. Therefore, speculation on the size of the world industry has been difficult in the context of the current study. Similar issues also apply to pumpkin seed imported into Australia. Anecdotal evidence suggests that most pumpkin seed and products are imported but being able to put any scale on potential for imports to be substituted by Australian grown product has again been difficult.

Oil pumpkin production is categorised more succinctly in several countries. This is probably because the cultivars often have a very specific end use that producers and marketers attempt to sell as a unique product. The Styria region of Austria is the original hull-less pumpkin seed production area and has been a long term producer of pumpkin seed oil. The United States Department of Agriculture prepared a report on the Austrian 'oil pumpkin' industry in 2004. They reported that the area planted to 'oil pumpkin' in Austria grew from 10,376 hectares in 2000 to 15,450 hectares in 2003 (GAIN 2004). This equated to oil production of 1.5 million litres (GAIN 2004). In neighbouring Slovenia, which was formerly part of the Styria region under previous border alignments, 'oil pumpkin' production is routinely over 2500 hectares per year.

Other countries that have had a tradition of oil produced from hull-less pumpkin seeds are Hungary, Northern Yugoslavia, Romania and the Ukraine (Winkler 2000). Jariene et al. (2007) noted that ‘oil pumpkin’ production is expanding in Hungary, South Ukraine and Czechoslovakia. Anecdotal evidence supports a contention that significant quantities of hull-less pumpkin seed originates from countries such as China, Russia and Turkey but it has again been difficult to put scale on the extent of these industries. Trial work reported in peer review articles also substantiates hull-less ‘oil pumpkin’ cultivars being grown in countries such as Lithuania, Poland and Germany but again no scale could be determined. In the United States only limited production occurs because there is not a large market for pumpkin seed oil (⁹J. Brent Loy pers. comm., 2 February 2011). Individuals or Companies in countries such as New Zealand, South Africa and Korea have also investigated the use of hull-less pumpkin seed cultivars but reference to these endeavours is not prominent in peer review literature.

Protection of a Brand

Cultivation of ‘oil pumpkins’ is a significant industry in the regions where the hull-less seed trait was first identified. Machinery contractors, processing mills, and ancillary industries are also directly involved with the industry. There is also a significant tourism industry as well as a number of festivals that revolve around pumpkin seed oil and the traditions related to the industry. There are prestigious competitions that reward excellence in the industry. A presentation at the First International Oil Pumpkin Conference by Cook (2000) highlighted a compelling marketing story for ‘oil pumpkin’ seed products. At the Conference Cook (2000) also detailed a rapid expansion of ‘oil pumpkin’ production beyond the Styria region. Producers in the traditional production areas were concerned about this expansion because they thought their market share would be compromised. At about the same time there was mounting evidence that oil produced from inferior hull-less pumpkin seed and light coloured hulled pumpkin seed was competing with the Styrian product. Some oil producers and suppliers were also beginning to blend pumpkin seed oil with other cheaper non-pumpkin seed oils. Pumpkin oil producers from the Styrian region sought to consolidate what they regarded as their unique industry beyond historical production areas by seeking a Stamp of Origin or geographical protection through the European Union.

A request for a Protected Stamp of Origin for pumpkin seed oil produced in the Styria region was filed in 1995 (Konrad 2000). A period of three years of data preparation was then required after the initial application and the European Union ultimately conferred a Stamp of Origin to the Styria region in 1998 (Konrad 2000). Since November 12 1998 the declaration of origin has been known as “*Steirisches Kurbiskernoel-geschuetzte geographische Angabe*” or “*Styrian Pumpkin-Seed Oil PGI.*” The letters g.g.A stand for geschuetzte geographische Angabe which translated denotes a protected declaration of origin or more literally Protected Geographical Indication (PGI). A specific numbered label is used for each bottle of pumpkin seed oil. The label can be used only for product which conforms to specifications designated in the Protected Geographical Indication listed under European Union Regulations (Steirisches–Kurbiskernoel g.g.A. 2010). The description of the detailed specifications for the registration of Styrian pumpkin seed oil as a protected geographical entity is on record at the Austrian Patent Office. The application detail lodged is Number 1215–GR/95 (BMLFUW 2009). The geographical protection enables specialist regional products to be clearly and distinctly identifiable from other competitors. This in theory minimises unfair competition.

Quite specific geographic inclusions are covered under the Stamp of Origin specifications. These include the mills that process the seed as well as actual production areas. For example, pumpkin seed oil using the “*Styrian Pumpkin-Seed Oil PGI.*” label must have been pressed exclusively in nominated and accredited mills from the Southern Styria and the Southern Burgenland regions of

⁹ J. Brent Loy is a professor of plant biology and genetics at University of New Hampshire

Austria. The production of the seed utilised for the oil can only occur in nominated locations from these same regions but also parts of the Lower Austria and Korneuburg–Stoekerau regions (BMLFUW 2009). By the Year 2000 the Stamp of Origin represented the interests of approximately 2,000 farmers in Styria, Burgenland and Lower Austria (Konrad 2000). These farmers accounted for approximately 70 percent of the region's 'oil pumpkin' production at the time (Konrad 2000). Thirty five oil mills were also aligned with the regional brand "*Styrian Pumpkin-Seed Oil PGI*" (GAIN 2004). Producers and processors are not obligated to use or be part of the regional brand. The headquarters of the organisation are based in Leibnitz in Styria. Approximately 1,000 of the members are involved in direct marketing of the pumpkin seed oil commodity (Steirisches–Kuerbiskernoel g.g.A. 2010). The organisation aims to expand the position and profile of the product internationally and strengthen the product's regional identity.

Effectively the Stamp of Origin ensures that the origin of each bottle of pumpkin oil can be traced from the farm of seed production through to the point of sale. It ensures the implementation of particular quality standards within a defined geographical area. Rigorous quality assurance protocols are required under the Stamp of Origin. Each bottle of pumpkin oil produced under the Stamp of Origin is numbered to facilitate traceability. The brand guarantees that the seed was produced and pressed within the specific inclusion area. The brand also guarantees that the oil presented is pure pumpkin seed oil originating from the first pressing of a manufacturing press (GAIN 2004). The brand guarantees that inferior pumpkin seed or other additives such as sunflower or canola oil are not used in the pumpkin oil presented for market.

Results

The desktop review has established that the production of edible pumpkin seed is theoretically feasible in Australian conditions. Past experience and the recent semi commercial demonstration block at Myrtleford North East Victoria also confirmed this from a practical perspective. The question of whether an Australian edible pumpkin seed production industry can be scaled up relates more so to market potential and the competitiveness of Australian product with world markets.

This project has established some baseline information on the use and production of pumpkin seed as an edible food source or processing entity in Australia. Some of the background of international pumpkin seed production have been summarised in order to be able to qualify questions relating to a potential Australian production industry. Basic agronomic practices for cucurbit production were assessed as part of the current study. These were incorporated into a semi commercial demonstration block in the former tobacco production area of Myrtleford in North East Victoria. The demonstration block was established and managed by a skilled horticulturalist without previous cucurbit experience. The Myrtleford area is not a recognised cucurbit production area. Production notes relating to this demonstration have been retained by the research organisation and a pictorial overview has been included as an Appendix item of this project report. Costs associated with the demonstration have not been accurately calculated. Readers will possibly be interested in returns or at least potential returns.

In the early stages of a new industry the return per kilogram of dried pumpkin seed will be what the purchaser is willing to pay. Having said that, a potential purchaser will assess seed quality, seed supply reliability, and perhaps an element of a 'Buy Australian' sentiment, in order to determine what they are willing to pay. An arrangement based on co-operation would probably be the preferred platform for initial production. It is unlikely a production industry could be established purely on speculative grounds or without some value adding intentions in mind.

Significant quantities of pumpkin seed are available on world markets. Some of this seed is derived from the cultivation of pumpkin cultivars grown specifically to harvest the seed. A proportion of it is a by-product of pumpkin flesh production. Viable Australian production of pumpkin seed would require a scale that could incorporate mechanisation. This would need to occur in conjunction with well managed field practices and the use of high seed yielding varieties. Another platform on which Australian pumpkin seed production could potentially compete with imported product is by establishing and marketing some point of difference. A seed type or seed quality attribute could be potential points of difference.

Considerable effort was made in this project to highlight the use of hull-less pumpkin seed cultivars as a source of edible pumpkin seed in Australian conditions. This feature is a clear point of difference that may contribute to the niche aspects of the crop and in turn contribute to viability for Australian producers. Dark coloured pumpkin seed oil is produced from this seed type in Central Europe. Oil production is a significant industry in Europe but the seed can also be used as a snack food and for many other purposes. Significant research has been undertaken in Central Europe to develop cultivars that produce seed with yield or quality attributes that make it a widely produced and keenly marketed commodity.

It is difficult to nominate a preferred geographical location for edible pumpkin seed production in Australia based on the current study. There is little doubt that expertise in traditional cucurbit production areas would lend itself well to edible seed production if viability could be proven. Some farmers with this expertise would have the industry knowledge and equipment to cope well with seed production. On the other hand publications originating from Central European 'oil pumpkin' production areas routinely link pumpkin seed oil quality to the climatic attributes of the area. This outlook will need to be assessed further under Australian conditions if oil is the production aim. It

could ultimately mean that production may in fact be better suited to some geographical areas that are not currently mainstream cucurbit production areas.

In some respects the use of Australian grown pumpkin seed or pumpkin seed products will be a marketing exercise. This in turn will have an impact on the likelihood of an expansion in field production. The pumpkin seed oil for example is a specialist product. Whilst common in some European countries, it is a relatively new food experience in Australia and so may have the potential to excite chefs, epicureans and foodies. On the other hand, the nutritional attributes of pumpkin seed and its increasing use in the pharmaceutical industry are also grounds to further examine the benefits of Australian production more generally.

Implications

The question relating to whether pumpkin seed production is a viable pursuit for Australian producers remains unanswered. A desire by consumers to 'Buy Australian' would be a logical consumer-led impetus to an Australian production industry in the short term. If a fledgling production and processing industry could continue with a 'Buy Australian' platform, the implications for future expansion of production and processing are encouraging. The study has highlighted that there are cultivars available internationally that have been developed specifically for high seed yield or some chemical attribute. Maximising seed yield would be critical for any Australian pumpkin seed producer. This is because the difficulty competing on price with imported pumpkin seed would only be exacerbated by low yield in Australian production situations. Internationally, there are research programs that deal exclusively with maximising the yield and quality attributes of pumpkin seed production. There is undoubtedly much to be learnt through collaboration with some of these organisations or through collaborations with other key industry personnel. As with any field of expertise a small number of the same names keep emerging in peer reviewed articles. The authors referred to throughout the current study relating to pumpkin seed production indicated there are acknowledged experts in that field. Interaction with some of these individuals or their organisations could provide breakthrough technologies that would enable quantum improvement in current field production or value adding techniques. If the combinations of high yield, high quality attributes, and quality assurance could be linked with a 'Buy Australian' philosophy, the genesis of an expanded local production and processing pumpkin seed industry could be in the offing.

This study has emphasised the difficulties of developing a new enterprise. Pumpkin seed as a commodity was new to the North East region of Victoria and new to the farmers who co-operated with the demonstration trial. There was a sound platform that helped initiate the current project because there was a willing purchaser who sought Australian product grown in a cool climate location, and a group of highly experienced farmers who have extensive expertise in irrigated row crop production. The purchaser-producer link was important in this instance to help establish a demonstration block in a new production area. Instant viability is elusive. Perseverance and a thirst for knowledge will be critical to maintain the momentum for a broader Australian production pumpkin seed industry.

This study is an example of an endeavour that would benefit from continued recognition by government at all levels. There is a good mix of production potential, a healthy product, and even tourism opportunities. The study has again clearly demonstrated that new diversification presents considerable challenges to landholders, processors and marketers. In the case of former tobacco farmers in North East Victoria, only a small number have shown a willingness to try new production pursuits; they have been risk averse. Realistically these farmers are not going to compete with established horticultural production enterprises in mainstream vegetable and fruit crops because generally their farm size is unsuitable, they lack industry experience, and markets are difficult to penetrate. Therefore, a new niche type activity such as pumpkin seed production would be a good fit for the area but only if viability can be demonstrated. Recognition by government is another reason why the current project was a good one. It enabled knowledge to be developed whilst at the same time providing a degree of support for a field demonstration. Without future support, production of pumpkin seed in North East Victoria area, and perhaps more broadly, could falter quickly because career farmers are generally unwilling to persist with new production pursuits if returns do not quickly accompany their risk. Therefore, this project has been a useful model for landowners in North East Victoria because it has given an insight into some of the problems confronting farmers who want to diversify. If commercial pumpkin seed production is to continue or expand further, work needs to be undertaken in a range of areas.

Recommendations

Dedicated edible pumpkin seed production is currently not a significant industry in Australia. Therefore, almost every aspect of Australian pumpkin seed production, processing and marketing could potentially benefit through collaboration with key research and industry personnel from recognised international production areas. Based on 'The Potential to Produce Processing Pumpkin Seed in North East Victoria, it is recommended that the following future activities be undertaken or considered as part of the process to assist development of an edible pumpkin seed production industry in Australia:

- Assess hull-less pumpkin seed cultivars originating from European 'oil pumpkin' plant breeding programs High yield could be a useful risk management strategy for potential Australian producers. [Late in the current study the authors became aware that a privately owned plant breeding company based in New Zealand has been developing and trialling hybrid hull-less seed pumpkin cultivars for the European 'oil pumpkin' industry. Collaboration with this company should be considered]
- Assess pumpkin cultivars originating from the University of New Hampshire plant breeding program for the production of pumpkin snack seed. Cultivars developed from the University program are reputed to be higher seed yielding than the European 'oil pumpkin' cultivars. [It is important to note that the United States pumpkin snack seed market is quite different to the European 'oil pumpkin' seed market]
- Refine agronomic practices relating to the production of edible pumpkin seed. This would be particularly relevant if introductions of new cultivars occurred. Practices that require improvement include plant spacing layouts as well as the interaction of plant nutrition with seed quality
- Benchmark the chemical composition of Australian grown pumpkin seed. This benchmarking would measure variability in chemical attributes across cultivars and in turn determine if there are potential benefits through cultivar selection. Australian pumpkin seed chemical data would build knowledge on cultivar and environment interactions as well as being a useful comparison to European analyses
- Develop protocols for the post-harvest and handling of harvested pumpkin seed. This should include precise detail on seed washing procedures, seed drying temperature and seed storage requirements
- Conduct a study tour to examine aspects of the Central European 'oil pumpkin' industry. Study parameters should include agronomic practices, the processing industry, marketing strategies and current research including cultivar development and seed chemistry. (Collaboration with the one known 'oil pumpkin' producer in New Zealand could be a useful endeavour too)
- Develop project proposals to secure ongoing support and commitment from government so commercial edible pumpkin seed production and processing can be further assessed and developed
- Use this project as a model for former North East Victorian tobacco growers to examine new and /or niche crops for the area
- Examine aspects of pumpkin seed quality assurance. This should include an investigation of whether past pesticide use may impact on pumpkin seed acceptability. It should also include discussions with the Australian Pesticides and Veterinary Medicines Authority and Food Standards Australia New Zealand relating to the appropriate classification category for pumpkin seed and pumpkin seed commodities (such as oil). This would help determine if existing Maximum Residue Limits apply or if the establishment of Extraneous Residue Limits (ERL) are necessary.

Appendix



Figure 2: First seeding of *Cucurbita pepo* subsp. *pepo* var. *styriaca* l. Greb at Myrtleford (18 November 2010)



Figure 3: Seedlings two weeks post planting



Figure 4: Pumpkin development four weeks post planting



Figure 5: Flowering commenced approximately six weeks post planting



Figure 6: Early fruit development commenced approximately eight weeks post planting



Figure 7: Early signs of fruit maturation occurred approximately twelve weeks post planting



Figure 8: Once seed maturity was confirmed the pumpkins were machine windrowed and allowed to 'sit' for a few days prior to mechanical harvest (approximately eighteen weeks post planting)



Figure 9: Mechanical harvest commenced approximately nineteen weeks post planting



Figure 10: Side view of mechanical harvester in operation



Figure 11: Rear view of mechanical harvester in operation



Figure 12: The harvested pumpkin seed with remnants of the pumpkin flesh ready to be augered into bins



Figure 13: Once the pumpkin seed was transferred to a bin it was allowed to 'sit' (under cover) for approximately 24 hours prior to washing



Figure 14: Hand washing of the pumpkin seed removed remnants of pumpkin flesh (this operation can be mechanised)



Figure 15: The washed pumpkin seed was transferred to a drying facility for up to 48 hours (this operation can be further mechanised)



Figure 16: Following the drying procedure the pumpkin seed was prepared for short term storage prior to colour sorting and 'value adding'



Figure 17: Value adding of pumpkin seed can include oil and snack seed products [photograph series supplied by Sharan West Australian Pumpkin Seed Company]

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The Potential to Produce Pumpkin Seed for Processing in North East Victoria

by G.G. Baxter, K. Murphy and A. Paech

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An established pumpkin seed processing company, looking to source additional Australian-grown pumpkin seed for its operation, has identified a number of potential future production areas, including the north east of Victoria. For farmers on ex-tobacco farms in the Ovens, King and Kiewa valleys, their conversion to the production of pumpkin seed potentially fits well with their region and circumstances.

This report summarises the background and intricacies of edible pumpkin seed production and processing. This report includes preliminary market research and value chain analysis and offers recommendations on the potential for production in Australia.

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