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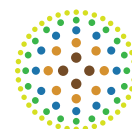
Rural Industries Research and
Development Corporation



Australian Royal Jelly

Market Opportunity Assessment based on production that uses new labour saving technology

By Michael Clarke and Peter McDonald



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Foreword

Royal jelly is a high value apiary product not currently produced in Australia. It is used both as a health supplement and an ingredient in cosmetic preparations.

Australian royal jelly production has been hampered by the labour intensive nature of its production and the high cost of Australian labour. A study tour completed under the Australia-China Agricultural Cooperation Agreement by Australian beekeepers and a honey bee technical specialist identified new prototype technology capable of stripping much of the labour from royal jelly production.

As a consequence RIRDC supported this study to identify the size of the potential market for Australian produced royal jelly and to what extent the economics of production change with new technology.

The study shows that the breakeven cost of supply is substantially less using the new technology but that production costs are more than the retail price of imported alternatives.

Further research should now focus on additional innovations that may, in the longer term, work in favour of an even lower Australian royal jelly production cost. These include superior genetics, colony manipulation and innovative hive technology.

This report is an addition to RIRDC's diverse range of over 2000 research publications and it forms part of our Honey Bee and Pollination R&D program, which aims to support research, development and extension that will secure a productive, sustainable and more profitable Australian beekeeping industry and secure the pollination of Australia's horticultural and agricultural crops.

RIRDC's publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

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Abbreviations

ABS	Australian Bureau of Statistics
DPI	Department of Primary Industries
EFSA	European Food Safety Authority
FAO	Food and Agriculture Organisation of the United Nations
FDA	United States Food and Drug Authority
FSANZ	Food Standards Australia New Zealand
mg	milligrams
RD&E	Research, Development and Extension
RIRDC	Rural Industries Research and Development Corporation

Executive Summary

What the report is about

This report investigates the size of the international royal jelly market, the size of the potential opportunity for Australian royal jelly and to what extent the economics of production change with new technology.

Who is the report targeted at?

The report is targeted at Australian beekeepers with an interest in developing additional high value apiary products. The report is particularly relevant to queen bee breeders who might most easily incorporate royal jelly production into their existing operations.

Where are the relevant industries located in Australia

Relevant beekeepers and queen bee breeders are located Australia wide. There are queen bee breeders in all Australian states and the Australian Capital Territory.

Background

Royal jelly is collected from honey bee queen cells and used as a human nutrition supplement and ingredient in cosmetic preparations. To date Australian royal jelly production has been limited by the need for hand grafting larvae, manual extraction of royal jelly and the high cost of Australian labour.

New technology developed in China shows potential for reduction in the labour required to produce royal jelly. The technology was reviewed in China by a delegation of Australian beekeepers and NSW Department of Primary Industries Technical Specialist Honey Bees, Dr Doug Somerville as part of the Australia – China Agricultural Cooperation Agreement. The equipment was brought to Australia by its inventor Mr Li Zhu of the Bao Chun Bee Products Company and a prototype was provided to Victorian beekeeper Peter McDonald for trialling in Australia. Subsequently a number of Australian beekeepers have expressed interest in royal jelly production using the Chinese equipment.

Objectives

The objectives of this study were to:

1. Investigate the market for Australian produced royal jelly using new labour saving equipment imported from China
2. Understand the cost of production of royal jelly produced in Australia with this new technology.

Methods used

A literature review was undertaken to understand the size of the international market for royal jelly and the opportunity for Australian production. Royal jelly production equipment was reviewed in Castlemaine Victoria with beekeeper Peter McDonald. A preliminary analysis was completed to determine the cost of royal jelly production with the new Chinese technology and whether Australian royal jelly could be competitive in domestic and export markets. Drafts of the analysis were shared with the industry and changes made as part of the feedback received. In addition to the final RIRDC report a short four page summary was produced outlining market opportunity and aimed at industry awareness raising.

Key findings

World production of royal jelly is estimated at 4,000 tonnes per annum with a wholesale value of \$US135 million. China produces an estimated 3,500 tonnes of royal jelly and other large producers include Vietnam, Taiwan, Japan and Korea. Royal jelly consumption and export is dominated by China. Japan is the world's largest importer of royal jelly purchasing an estimated 1,000 tonnes per annum. After Japan the biggest consumers of royal jelly are Europe and North America where the product is used mostly as an input in the manufacture of cosmetic preparations.

Price through the value chain is estimated in Australian dollars at \$17/kg farm gate China, \$59/kg factory price China, \$100/kg delivered Australia, \$138/kg wholesale Australia and \$296/kg retail. Potential Australian royal jelly producers will need to establish both low cost production systems and or a price premium over competitively priced Chinese product if they are to establish a profitable royal jelly industry.

Currently there is no domestic production of royal jelly although royal jelly has been produced and exported in the past by Browns Bees of Mendooran NSW. The Australian royal jelly market is dominated by the health supplement sector and products include fresh royal jelly and royal jelly capsules. The cosmetics preparation sector includes products which typically contain less than 1% royal jelly usually in a freeze dried form. Both the health supplement and cosmetic preparation sectors are growing strongly. China is able to supply royal jelly very cost effectively to the Australian market and counterfeit 'Australian' royal jelly is openly sold in China.

Exports of genuine Australian royal jelly would find a ready market in China (125 tonne per annum) and Japan (46 tonne per annum) with niche sales possible in other parts of Asia, Western Europe and North America. The overall market for Australian produced royal jelly, including domestic sales (2 tonnes per annum), is estimated at approximately 175 tonne per annum.

Traditional royal jelly production requires five key steps: (1) queen frame set up (2) manually grafting day-old worker bee larvae into the artificial queen cells (3) introducing the frame into the colony and feeding the colony (4) removing the queen populated frame from the colony (5) harvest and storage. New prototype technology developed in China by the Bao Chun Bee Products Company offers labour saving for the two most labour-intensive steps – manually grafting day old worker bee larvae (step 2) and harvesting royal jelly (step 5).

Using the Bao Chun Bee Products Company Royal Jelly Machine significantly reduces the amount of labour required to produce royal jelly. Total beekeeper time required per hive per production cycle is estimated at 1.3 hours. However, at an assumed labour cost of \$25/hour plus queen and sugar feeding costs, indicative breakeven cost is approximately \$520/kg. This price is substantially higher than the Australian retail price for Chinese produced royal jelly i.e. \$296/kg.

Implications for relevant stakeholders

While a premium might be anticipated for Australian produced and certified royal jelly the market is known to be price sensitive and it is unlikely that Australian produced royal jelly will find a buyer at \$520/kg.

Nevertheless there are a number of innovations in addition to the Bao Chun Royal Jelly Machine that may, in the longer term, work in favour of a lower Australian royal jelly production cost. These include superior genetics, colony manipulation and innovative hive technology.

Recommendations

This study recommends that RIRDC give consideration to the funding of a small trial using the Bao Chun Royal Jelly Machine to confirm the cost of production estimates used in this report.

Contents

- Executive Summary..... v**
- 1. Introduction 1**
 - Project background 1
 - Study approach..... 1
- 2. Royal jelly, human consumption and product form 2**
 - Product description 2
 - Human consumption 2
 - Product form 3
- 3. International market for royal jelly 4**
 - World production and industry value..... 4
 - Exporting countries..... 5
 - World consumption..... 5
 - Changes in wholesale price..... 5
 - Price through the value chain..... 5
 - Requirements for Australian beekeeper success 6
- 4. Royal jelly market opportunity for Australian beekeepers..... 6**
 - Domestic market 6
 - Export market..... 8
 - Possible size of Australian market opportunity 9
 - Pricing Australian produced royal jelly 9
- 5. Royal jelly production and relevant technology 10**
 - Traditional approaches used to produce royal jelly 10
 - Profitable supply price using traditional approaches 12
 - New Chinese technology for royal jelly production 12
 - Cost of royal jelly production using labour saving technology 15
- 6. Viability of an Australian royal jelly producing industry 16**
- 7. Study conclusions and recommendations..... 18**
- References 18**

1. Introduction

This project has been completed as part of the Rural Industries Research and Development Corporation (RIRDC) Honey Bee and Pollination Program. The aim of the program is to support research, development and extension (RD&E) that will secure a productive, sustainable and more profitable Australian beekeeping industry and ensure the pollination of Australia's horticultural and agricultural crops.

Objective 2 of the Honey Bee and Pollination Program 5 Year RD&E Plan 2015-19 is to 'Facilitate the development of at least one new Australian apiary product'. Consistent with Objective 2, Research Priorities for 2015, identify the need to 'Support the development of Australian apiary products'.

Consequently the objectives of this project were to:

1. Investigate the market for Australian produced royal jelly using new labour saving equipment imported from China
2. Understand the cost of production of royal jelly produced in Australia with this new technology.

The purpose of this project was to investigate the size of the international royal jelly market, the size of the potential opportunity for Australian royal jelly and to what extent the economics of production change with new technology.

Project background

Royal jelly is collected from honey bee queen cells and used as a human nutrition supplement and ingredient in cosmetic preparations. To date Australian royal jelly production has been limited by the need for hand grafting larvae, manual extraction of royal jelly and the high cost of Australian labour.

New technology developed in China shows potential for reduction of the labour required to produce royal jelly. The technology was reviewed in China by a delegation of Australian beekeepers and NSW Department of Primary Industries (DPI) Technical Specialist Honey Bees, Dr Doug Somerville as part of the Australia – China Agricultural Cooperation Agreement (Somerville June 2013). The equipment was brought to Australia by its inventor Mr Li Zhu of the Bao Chun Bee Products Company and a prototype was provided to Victorian beekeeper Peter McDonald for trialling in Australia. Subsequently a number of Australian beekeepers have expressed interest in royal jelly production using the Chinese equipment.

Study approach

Project objectives were delivered through the discharge of four tasks:

1. Literature review to understand the size of the international market for royal jelly and the opportunity for Australian production
2. Review of the Chinese technology in Castlemaine Victoria with beekeeper Peter McDonald
3. Preliminary analysis to determine cost of production using the new technology and whether Australian royal jelly could be competitive in domestic and export markets
4. Preparation of a project report and short four page summary outlining market opportunity and aimed at industry awareness raising.

2. Royal jelly, human consumption and product form

Product description

Royal jelly is a honey bee secretion that is used in the nutrition of larvae, the creation of a new queen bee and the food for the adult queen bee throughout her life. Royal jelly is secreted from the glands in the hypopharynx in the worker bees' head. Royal jelly is fed to all larvae in the colony regardless of sex or caste during the first three days of life.

When worker bees sense the need for a replacement queen they choose several one, two or three day old larvae and feed them large amounts of royal jelly in specially constructed queen cells. Feeding larvae royal jelly beyond day three leads to queen morphology. Queen morphology includes the development of egg laying ovaries.

Royal jelly is creamy in appearance and consistency with a strong astringent/acidic and very mildly venomous flavour. Its quality is reasonably consistent and is influenced by the pollen diet and the general health of the secreting bees. The quantity of royal jelly produced per queen cell varies considerably based on the number of young nurse bees and the amount of food available. Abundant pollen and nectar will maximise royal jelly production. Royal jelly typically consists of water (67%), crude protein including many different types of amino acids (12.5%), simple sugars (11%) and fatty acids (5%). Royal jelly also contains trace elements, some enzymes, antibacterial and antibiotic components, pantothenic acid (vitamin B5), pyridoxine (vitamin B6) and trace amounts of vitamin C (Blackiston 2009).

Royal jelly is only collected by humans from queen cells where it is deposited in larger volumes and in advance of larvae consumption. Well managed hives are able to produce up to 500 grams of royal jelly per year and production is over a 5-6 month spring and summer period (https://en.wikipedia.org/wiki/Royal_jelly). The small amount of production and high requirement for labour for grafting queen cells and manually extracting royal jelly means that the resultant product is expensive to produce.

Human consumption

Royal jelly is collected and sold as a human nutrition supplement and ingredient in cosmetic preparations. Benefits claimed by marketers of royal jelly include improved health, increased body mass, enhanced fertility and additional longevity. Cosmetics containing royal jelly are said to have anti-aging qualities. In many countries, royal jelly has been promoted as a commercially available medicine, health food, and cosmetic (as an emollient, moisturiser, and nourishing substance). It is used in traditional medicine for longevity in Europe and Asia. Royal jelly has been sold as a skin tonic and hair growth stimulant (<https://www.drugs.com/npc/royal-jelly.html>).

Royal jelly has been studied for a variety of actions, including antibiotic, antitumor, lowering blood pressure, and regulating the immune system. Additionally, effects on cholesterol, insulin-like action, and on the nervous system and female hormonal activity have been demonstrated. However, clinical trials are lacking (<https://www.drugs.com/npc/royal-jelly.html>).

Furthermore, the European Food Safety Authority (EFSA) has concluded that the current evidence does not support the claim that consuming royal jelly will give health benefits in humans (EFSA Journal 2011). In the United States the Food and Drug Administration (FDA) has taken legal action against companies that have used unfounded claims of health benefits to market royal jelly products (FDA 2010). In Australia FSANZ requires that food containing royal jelly include a warning statement, which states that: *This product contains royal jelly which has been reported to cause severe*

allergic reactions and, in rare cases, fatalities, especially in asthma and allergy sufferers.
<http://www.foodstandards.gov.au/consumer/labelling/advisory/Pages/default.aspx>

Product form

The proportions of royal jelly in a dietary product are usually adjusted to provide a dose equivalent to 200 to 300 milligrams (mg) fresh weight of royal jelly. The product is usually sold as either a capsule or in freeze dried form. Freeze drying produces a white friable powder. Other consumer ready product forms include tablets, honey with royal jelly, yoghurt with royal jelly, jellies and soft caramels, liquid preparations and dried juice concentrate (Piana, FAO 1993).

Royal jelly is also sold as a fresh liquid that is consumed by the teaspoon. Royal jelly sold in China in the queen cells it was produced in is shown in Figure 2.1.

Figure 2.1 Royal Jelly Sold in Queen Cells in Retail Ready pack in China



Photo credit: Dr. Doug Somerville June 2013

Royal jelly can be easily added to any cosmetic preparation, usually at a concentration of 0.1 to 1% fresh or 0.03 to 0.3% freeze-dried royal jelly (Piana, FAO 1993).

3. International market for royal jelly

Royal jelly is an internationally traded commodity for which no official market data exists (Sabatini *et al* 2009). As a consequence market data has been assembled from a range of unofficial sources and reported where the metric is consistent across multiple publications.

International market analysis addresses world production, exports, consumption, changes in wholesale price, price through the value chain and requirements for Australian beekeeper success.

World production and industry value

World royal jelly production was most recently estimated in 2012 at approximately 4,000 tonnes. World production was dominated by China - Table 3.1.

Table 3.1 Royal Jelly World Production 1984 and 2012 (Tonne)

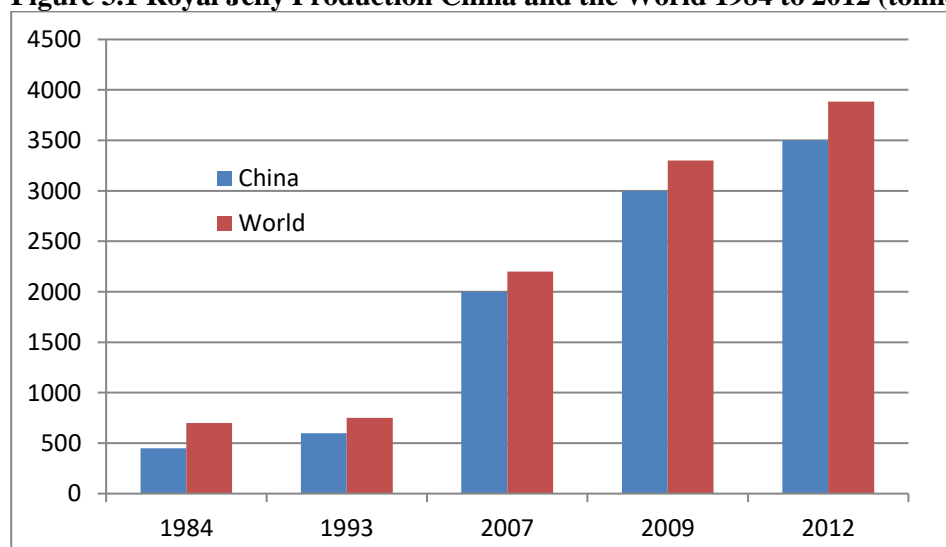
Country	1984	2012
China	450	3,500
Vietnam	20	100
Taiwan	140	80
Japan	46	75
Korea	20	50
Other (including Eastern Europe, France, Italy and Mexico)	24	80
World production	700	3,885

Source: Crane 1990 and various references including Cao *et al* 2016 and Sabatini *et al* 2009

Other important producers of royal jelly included Vietnam, Taiwan, Japan and Korea. Royal jelly production also occurred in Eastern Europe, Western Europe, and North America (Sabatini *et al* 2009).

China’s production and hence world production of royal jelly has increased on the back of a concerted R&D effort and the creation of a high royal jelly yielding line of honey bees - *Apis mellifera ligustica Spinola, 1806*. High royal jelly yielding honey bees were developed and subsequently adopted by Chinese beekeepers in the 1980s (Cao *et al* 2016). Sedentary Chinese beekeepers using this line of honey bees are able to make a reasonable living from their royal jelly sales (Somerville June 2013). The impact of high royal jelly yielding bees may be one factor behind the increase in China and world royal jelly production since the early 1990s - Figure 3.1.

Figure 3.1 Royal Jelly Production China and the World 1984 to 2012 (tonnes)



Source: Crane 1990, Sabatini *et al* 2009, Cao *et al* 2016

Bogdanov (2012) estimated world royal jelly production in 2012 at approximately 4,000 tonnes with a total wholesale value of \$US135 million.

Exporting countries

China is the world's largest exporter of royal jelly. Other important exporters include Vietnam, Taiwan, Japan and Korea (Sabatini *et al* 2009).

World consumption

Most of the world's royal jelly is consumed in China with much of the balance exported to Japan (Somerville September 2013). Japan is the world's largest royal jelly importer consuming an estimated 300 tonnes in 1996, 600 tonnes in 2003 and 1,000 tonnes in 2012 (AgEconPlus estimate).

After Japan, the biggest market for royal jelly is the European and North American cosmetics sector. Consumption in the cosmetics sector is also increasing in Asia, especially in Thailand which has a substantial cosmetics manufacturing industry (Piana 1993).

Changes in wholesale price

The world wholesale price for royal jelly has declined since the 1960s but has stabilised in recent years – Table 3.2.

Table 3.2 Changes in the Wholesale Price of Royal Jelly Over Time (\$US/kg)

Year	Price
1964	180 to 400
1993	30 to 80
2012	20 to 40
2016	30 to 60

Source: Bogdanov, 2012 and Alibaba 2016 <https://www.alibaba.com/showroom/wholesale-royal-jelly.html>

High prices in the 1960s were attributed to publicity linked to the successful treatment of Pope Pius XII for age and lethargy with royal jelly. Subsequent declines in price have been attributed to the growth of an efficient Chinese industry and a lack of substantiation for royal jelly's health properties (Piana 1993).

China supplies the world market with royal jelly at highly competitive prices that make it difficult for producers in other countries to compete (Sabatini *et al* 2009).

In 2016 a review of the market leading Chinese website Alibaba reveals that all forty one of the wholesale royal jelly listed suppliers are Chinese firms (<https://www.alibaba.com/showroom/wholesale-royal-jelly.html>). This is not the case when the site is reviewed for other specialised animal products e.g. camel milk which is available from twelve countries of origin including China.

Price through the value chain

Table 3.3 shows royal jelly prices through the value chain.

Table 3.3 Royal Jelly Price through the Value Chain (Australian \$/kg)

Value Chain Link	Source of Information and Explanation of Data	Estimate
Farm gate price in China	Farm gate value of royal jelly in China is 100RMB/kg, 6RMB = \$A1 (Somerville September 2013)	\$16.66
Factory price China – excluding insurance, customs clearance and freight	\$US30 to \$60/kg in Table 3.2 and an exchange rate of \$A1 = \$US0.77	\$58.72
Factory price delivered Australia	Personal communication Australian royal jelly importer November 2016	\$100.00
Wholesale price in Australia	Personal communication Australian royal jelly importer November 2016	\$138.49
Retail price equivalent based on products sold in Australia	Average of data provided in Table 4.1 for health sector products	\$296.16

Requirements for Australian beekeeper success

Potential Australian royal jelly producers will need to establish both low cost production systems and or a price premium over competitively priced Chinese product if they are to establish a profitable royal jelly industry.

4. Royal jelly market opportunity for Australian beekeepers

The size of the market opportunity for Australian beekeepers producing royal jelly is examined from both a domestic and export market perspective.

Domestic market

Australia has not been a consistent producer of royal jelly. For a few years in the early 2000s, Browns Bees produced and exported royal jelly in Australia for local and export sale to the Middle East. Production ceased to be profitable when Middle East market conditions changed (Terry Brown, pers. comm. March 2017).

Historically newly arrived Asian and European migrants were most interested in royal jelly and small quantities were imported to meet their needs.

In 2016 the market has grown and includes both health supplement and cosmetic preparation sectors.

The dominant products in the health supplement sector are fresh royal jelly and royal jelly capsules. The average retail value of these products is close to \$300/kg – Table 4.1.

Table 4.1 Retail Products and Prices – Australian Royal Jelly Health Supplement Sector

Supplier	Product form	Price – Approximation (\$/kg)
Super Bee www.superbee.com.au	\$152.36 for 500 grams of ‘fresh royal jelly’	\$304.72
Super Bee www.superbee.com.au	\$276.00 for 1 kg of ‘fresh royal jelly’	\$276.00
Vitamin King www.vitaminking.com.au	\$27.50 for 100 grams of ‘fresh royal jelly’	\$275.00
Vitamin King www.vitaminking.com.au	\$99.95 for 365 grams of ‘fresh royal jelly’	\$273.80
NZ Pure Health Com www.NZpurehealth.com	\$31.72 for 100 capsules each containing 1 gram of royal jelly	\$317.20
Bee Vitamins www.beevitamins.com.au	\$125.95 for 365 soft capsules	\$345.07
Mr Vitamins www.mrvitamins.com	\$29.95 for 180 capsules each containing 0.6 grams of royal jelly	\$277.31
Pharmacy 4 less Top Ryde NSW	\$11.99 for 60 soft jell capsules each containing 0.6 grams of royal jelly	\$333.06
Pharmacy 4 less Top Ryde NSW	\$79.99 for 365 soft jell capsules each containing 0.6 grams of royal jelly	\$365.25
Costco Wholesale Buyers Club, Auburn NSW	\$39.99 for 365 soft jell capsules each containing 0.6 grams of royal jelly	\$182.60
Average retail price		\$296.16

Source: Online sources and a small retail survey, November 2016

The cosmetic preparation sector includes a range of cleansers, toners, exfoliates, moisturising skin balms, skin repair, lip balms, eye cream and insect repelling skin care. Typically these products include less than 1% royal jelly and the royal jelly used is imported in either fresh or more typically freeze dried form – Table 4.2.

Table 4.2 Retail Products and Prices – Australian Royal Jelly Cosmetic Preparation Sector

Supplier	Product form
Queen Bee Secretes www.queenbeesecretes.com.au	<ul style="list-style-type: none"> • \$35 per 50 gram tin of royal jelly day and night balm for face, neck, hands and nails ‘royal jelly is the elixir of life and is nature’s alternative to Botox’. • \$30 per 25 gram tin of eye cream containing royal jelly and for use on fine lines around the eyes and mouth • \$17.95 for 25 gram tin mosquito repellent containing royal jelly • \$17.95 for 25 gram tin of skin repair balm • \$16 for 20 gram tin of lip balm that includes ‘just a hint of lavender essential oil and royal jelly’ • \$17.95 for 25 gram tin of muscle and joint rub balm containing royal jelly plus certified organic botanicals
Bert’s Bees http://sarah-thescienceofbeauty.blogspot.com.au/2011/04/burts-bees-radiance-range.html	<ul style="list-style-type: none"> • \$24.95 for 175 ml of facial cleanser incorporating royal jelly • \$24.95 for 175 ml of toner incorporating royal jelly • \$34.95 for 13 ml of radiance serum with royal jelly that ‘plumps’ • \$34.95 for 14 grams of eye cream incorporating royal jelly • \$39.95 for 55 grams day cream with sun screen and royal jelly • \$19.95 for 350 ml exfoliating body wash incorporating royal jelly

Source: Online sources, November 2016

Wholesale Market

Advice provided by a large Australian importer of royal jelly:

- There is no Australian produced royal jelly, the Australian market is supplied solely by China
- Importation is dominated by those supplying the Australian health supplement sector
- Royal jelly is imported into Australia and re-exported to places like Japan and Korea
- The factory that supplies me in China claims to supply one quarter of world royal jelly output
- On this basis I would estimate that the current world market is greater than 4,000 tonnes
- Fake royal jelly is a huge problem and much of the product for sale on the internet is fake.
- Fake 'Australian' royal jelly is sold openly in China
- Royal jelly is a price driven sector and this will make it difficult for Australian produced royal jelly to compete at premium prices.

The importer would not be drawn on the size of the Australian market. AgEconPlus estimates the Australian royal jelly market at somewhere around 17 tonnes per annum for freeze dried product and 3 tonnes per annum for fresh royal jelly. Both products are on-sold to the health supplement and cosmetic preparation sectors.

Retail Market

Both the health supplement and cosmetic preparation sectors are growing strongly in Australia. For instance the vitamin and dietary supplements sector in Australia grew at 6% per annum in 2016 and the category continues to benefit from demand from Chinese consumers. The category witnessed a boom in 2015, growing at 27% in current value terms, with this largely attributed to Chinese consumers (Euromonitor, September 2016).

Due to Australia's strict food safety requirements and quarantine controls, Australian made products are highly sought after by Chinese consumers, who have become sceptical about products manufactured in their homeland. Demand derives from Chinese tourists, migrants and international students, as well as their families (Euromonitor, September 2016).

It has become common practice for Chinese shoppers to send products home for their families or take Australian-made vitamins and dietary supplements home to sell for a profit. In fact, the practice of 'suitcase trading' became apparent in 2015, with this involving Chinese consumers purchasing large quantities of vitamins and dietary supplements in Australia to sell on through online channels in China (Euromonitor, September 2016).

Export market

The export market for Australian produced royal jelly is likely to be China amongst middle and upper class consumers looking to meet their requirements for Chinese medicine health supplements from a trusted source.

This market is also likely to extend into Japan where regulators and fastidious consumers require the highest levels of traceability and food safety. Australian product has the potential to displace some Chinese royal jelly in Japan but is less likely to make in-roads against well regarded Japanese domestic product.

Niche export sales of royal jelly may also be possible in other parts of Asia – including Korea, and Taiwan as well as in Western Europe and North America. Sales in Western Europe and North America are likely to be into 'high end' cosmetics manufacture.

Possible size of Australian market opportunity

A possible sales profile for Australian produced royal jelly sold at premium prices and capturing a 10% share of domestic sales and a 5% slice of major world markets is presented in Table 4.3.

Table 4.3 Possible Market Size for Australian Produced Royal Jelly

Possible Market	Explanation for Market Estimate	Possible Market Size (kg/year)
Australian domestic market	<ul style="list-style-type: none"> Small market driven by sales of health supplements and natural beauty treatments, a portion of which may be interested in switching to 'clean and green' Australian sourced royal jelly Market estimated at a maximum of 20 tonne per annum, 10% of which may be prepared to pay a premium for Australian product 	2,000
China	<ul style="list-style-type: none"> China royal jelly production estimated at 3,500 tonnes per annum, 2,500 tonnes of which is consumed in China mainly in health supplements Concern expressed about the safety of Chinese made vitamins and dietary supplements would manifest itself as demand for higher cost Australian product and a 5% market share is estimated 	125,000
Japan	<ul style="list-style-type: none"> Japan royal jelly market estimated at 1,000 tonnes per annum, 75 tonnes of which is supplied with local product. Once again a desire to secure high quality 'clean and green' royal jelly from Australia creates a market niche – 5% of imported royal jelly 	46,250
Other	<ul style="list-style-type: none"> Miscellaneous opportunities including small volume sales into East Asia, Western Europe and North America 	500
Possible market size		173,750

Source: AgEconPlus analysis

A market of 173,750 kg for Australian produced royal jelly may be possible.

Pricing Australian produced royal jelly

Mr Li Zhu of the Bao Chun Bee Products Company in China, inventor of royal jelly extraction equipment and marketer of Chinese royal jelly has indicated an interest in sourcing and marketing Australian royal jelly. Mr Li Zhu would like to have royal jelly produced in Australia that he could export to China and Japan (Somerville June 2013).

Mr Li Zhu indicated an indicative 'farm gate' price of \$A66.66/kg (400RMB/kg) for Australian produced royal jelly to delegates on the Australia-China Agricultural Cooperation Agreement, Beekeeping Mission in 2013.

A 'farm gate' price of \$A66.66/kg for Australian produced royal jelly is four times the price of China produced royal jelly at 'farm gate' but less than the price of Chinese produced royal jelly delivered to an Australian wholesaler (see Table 3.3).

5. Royal jelly production and relevant technology

Traditional approaches used to produce royal jelly

The steps involved in producing royal jelly traditionally include¹:

1. Queen frame set-up
 - Setting up a modified movable frame with artificial queen cells into which day-old worker bee larvae can be grafted i.e. manually extracted from worker bee brood and placed in a queen cell.
 - In Europe this might involve placing 50 plastic queen cells on a single frame (Bogdanov 2012)
 - In China four double row bars of 66 queen cells, 264 queen cells in total, are added to a single frame (Figure 5.2, Photo 2).

2. Manually grafting day-old worker bee larvae into the artificial queen cells
 - This is a labour intensive process that involves manually removing day old larvae from colony worker bee comb and placing them into queen cells in an undamaged state.
 - In Europe some producers add a drop of royal jelly to the queen cell before the day-old larvae is added. Approximately 40 larvae survive to produce royal jelly and juvenile ‘queens’ (Bogdanov 2012).
 - In China a single frame with 264 queen cells will result in royal jelly production and juvenile ‘queens’ in between 200 and 250 cells.

3. Introducing the frame into the colony and feeding the colony
 - Introduce the frame with larvae populated queen cells into a suitably prepared colony
 - In Europe the colony might be queen-less and populated by young nurse bees. The nurse bees will start raising the queens and will deposit royal jelly into each queen cell. The queen-less colony will need to be regularly fed a diet of sugar syrup and pollen - 1 litre two to three times per week with access to an appropriate pollen supply. The queen-less nurse bee hive is without forager bees that can feed the colony (Bogdanov 2012).
 - In China a colony might be populated with two or more queens and the swarming impulse used to stimulate royal jelly production. Even under these conditions supplementary feeding with sugar syrup and pollen will be required (Somerville, pers. comm., March 017).

4. Remove the queen populated frame from the colony
 - After three days the maximum amount of royal jelly is deposited in the queen cell.
 - In Europe ‘queen’ larvae is removed and discarded. Each queen cell will contain about 0.3 grams of royal jelly (Bogdanov 2012).
 - In China queen cells might yield 1.0 gram of royal jelly - derived from Somerville (September 2013) which states – 30 to 40 hives daily produce 4 to 5 kg of royal jelly, each hive produces between 200 to 250 juvenile ‘queens’. Additional yield per queen cell is an important source of comparative advantage for China and stems from their program of selective breeding for

¹ Steps referenced for Europe and China have been cross checked with those described in the NSW DPI Queen Bee Breeding Handbook (NSW DPI 2016) and were found to be consistent.

royal jelly yield in the 1980s. Furthermore ‘queen’ larvae is recovered in China and eaten as a delicacy.

5. Harvest, processing and storage procedure

- In Europe royal jelly is removed from the uncapped queen cells using a pipette, small spatula or similar. Each queen cell needs to be manually emptied and once again this is a labour intensive process. Royal jelly is then filtered through a 0.2 mm mesh and refrigerated or frozen until transported to a further processing facility (Bogdanov 2012).
- In China royal jelly is traditionally extracted manually in the same manner as Europe – with a pipette or more typically a small ‘spoon’ (Figure 5.1). However, the royal jelly is not always filtered. A price premium may be received if royal jelly is left as ‘plugs’ that retain some of the form of a queen cell. This then reassures the buyer that nothing has been added to the royal jelly and that it is straight from the queen cell and the hive.

6. Seasonal per hive production

- Three day ‘grow out’ of queen larvae prior to royal jelly harvest allows for two production cycles per week over a 20 week production season in Europe yielding approximately 480 grams of royal jelly per hive per annum (0.3 grams of royal jelly per cell, 40 successful cells per hive, two production cycles per week for 20 weeks per year).
- This estimate is consistent with the literature ‘a well-managed hive during a season of 5–6 months can produce approximately 500 grams of royal jelly’ (https://en.wikipedia.org/wiki/Royal_jelly)
- Chinese per hive production with more productive bees (1 gram of royal jelly per cell rather than 0.3 grams) and more cells per hive (200 to 250 queen cells per hive rather than 40 cells per hive) will be much higher. Chinese royal jelly production typically takes place in a climate similar to Townsville Australia – a longer production season than that achieved in Europe.
- High productivity Chinese hives can each produce 7 kg of royal jelly in a season (Jianke 2001).

Figure 5.1 – Manual Extraction of Royal Jelly – Slow and Labour Intensive



Photo credit: Craig Klingner June 2013

Profitable supply price using traditional approaches

Terry Brown of Browns Bees Mendooran NSW and the only known past producer of royal jelly in Australia commented that the profitable supply price for royal jelly using traditional approaches was around \$1,000/kg and that the market was accustomed to paying approximately \$40/kg (personal communication March 2017).

New Chinese technology for royal jelly production

While highly productive Chinese bred honey bees have made royal jelly production an economic proposition in rural areas where labour costs have been low, mechanisation is required if the industry is to remain viable in China and is essential if a royal jelly industry is to be established in Australia.

New prototype technology developed in China by the Bao Chun Bee Products Company (<http://www.baochun.com.cn/>) offers labour saving potential for royal jelly production. Figure 5.2 uses photos to illustrate royal jelly production using the Bao Chun Royal Jelly Machine.

The patent technology offers labour saving for the two most labour-intensive steps associated with royal jelly production – manually grafting day old worker bee larvae (Step 2 in the traditional approach to producing royal jelly) and harvesting royal jelly (Step 5).

The technology is based on a modified hand operated centrifugal honey extractor that in addition to having ‘slots’ for two conventional frames of honey filled comb provides two additional modified ‘slots’, one for fitting four rows of empty queen cells and a section of filled brood comb and the other for extracting and filtering filled queen bee cells (Figure 5.2).

Four rows of empty queen cells and filled worker bee brood comb are fitted in a simple locking cassette. The cassette is slotted into the modified extractor and spun. Centrifugal force is used to spin the day old larvae out of the worker bee brood comb and into the empty queen cells. No labour for manually grafting day-old worker bee larvae into queen cells is required. If multiple larvae end up in a single queen cell, nurse bees will remove the less viable individual when the queen cells are placed back in the colony. Once filled, the four rows of queen cells are simply removed from the cassette and clipped onto a frame and inserted into a colony.

After three days the frame is removed from the colony, rows of queen cells are unclipped from the removable frame and fitted into a second cassette and slotted into the modified extractor and spun. Harvesting the royal jelly is accomplished without manual extraction labour.

Figure 5.2 – Royal Jelly Production Using New Technology - the Bao Chun Royal Jelly Machine

Photo 1: Cassette with worker bee brood and empty queen bee cells (fitted behind the worker bee brood) being inserted into the Bao Chun Royal Jelly Machine. Centrifugal force spins larvae from the brood comb and into the queen bee cells. Note conventional honey frames already in the Bao Chun Royal Jelly Machine to demonstrate that the machine can be used conventionally for honey extraction.



Photo credit: Michael Clarke February 2017

Photo 2 Royal jelly filled queen cells suitable for unclipping from the frame and fitting into a cassette and spinning in the Bao Chun Royal Jelly Machine. Note this frame shows only three occupied rows, a total of 198 cells (three double rows each with 66 cells). Space is available for addition of a fourth and even a fifth row. The amount of rows provided is dependent on the strength of the colony receiving the frame.



Photo credit: Craig Klingner June 2013

Photo 3: Cassette with royal jelly filled queen bee cells ready for extraction being fitted into the Bao Chun Royal Jelly Machine



Photo credit: Michael Clarke February 2017

Photo 4: Cassette removed from the Bao Chun Royal Jelly Machine and showing empty queen cells, filter, trapped queen larvae and recovered royal jelly



Photo credit: Trevor Monson June 2013

Photo 5: Royal jelly ready for sale in China. Note royal jelly extracted with the Bao Chun Royal Jelly Machine is of an even consistency and loses the 'plug' shape shown in this photo



Photo credit: Craig Klingner June 2013

Cost of royal jelly production using labour saving technology

To determine whether the Bao Chun Royal Jelly Machine changes the economics of Australian royal jelly production a preliminary cost analysis was completed with beekeeper Peter McDonald.

Production steps, assumptions and beekeeper time required are shown in Table 5.1.

Table 5.1 Cost of Royal Jelly Production in Australia Using the Bao Chun Machine

Production Steps and Assumptions	Beekeeper Input (hours/hive)
1. Day old worker bee larvae transferred into artificial queen cells <ul style="list-style-type: none"> • Brood comb removed from hive and cut to fit Bao Chun Machine cassette • Four double row bars of empty artificial queen cell fitted to cassette, cassette placed in Bao Chun Machine and spun • Assume artificial queen cells are purchased commercially for a nominal cost and reused multiple times 	0.5
2. Queen frame set-up <ul style="list-style-type: none"> • Queen cell double row bars containing day old larvae removed from cassette and fitted to a single frame; 66 queen cells per bar with four bars per frame for a total of 264 cells (not all of which will be occupied) 	0.1
3. Introduce the queen frame into the colony and feeding the colony <ul style="list-style-type: none"> • Slot frame into a double queen colony • The colony's swarming urge used to stimulate royal jelly production • Colony has both worker and nurse bees but supplementary sugar feeding is still required • Assume a second queen is purchased for the hive at a cost of \$30. However because the second queen lasts all year – 2 production cycles per week for 20 weeks – cost is reduced to approximately \$0.75 per production cycle • Assume sugar syrup consists of 2kg of sugar to 1kg of water and 1 litre used per production run with a cost of \$0.90/kg for sugar – cost of \$1.80 	0.2
4. Remove the queen populated frame from the colony and uncap the cells <ul style="list-style-type: none"> • Royal jelly filled frame replaced with a new frame of day old worker bees in queen cells • Four double row bars filled with royal jelly removed from the frame and uncapped using a standard uncapping knife 	0.3
5. Harvest, processing and storage <ul style="list-style-type: none"> • Uncapped double row bars fitted to Bao Chun Machine cassette, cassette fitted with filter and placed in the Bao Chun Machine and spun • Assume 200 to 250 queen cells per frame successfully populated and each cell generates 0.3 grams of royal jelly per cell • Cassette emptied into storage container for fresh royal jelly sale or freezing 	0.2
Total hours required per hive	1.3
Cost of labour per hive	\$25/hour
Cost of production labour	\$32.50
Cost of second queen	\$0.75
Cost of sugar feeding	\$1.80
Cost of production per hive (excluding extraction machine capital)	\$35.05
Production per hive <ul style="list-style-type: none"> • 0.3 grams royal jelly per cell by 225 successful cells per hive = 67.5 grams = 0.0675kg/hive 	0.0675kg
Price required for royal jelly production to break even <ul style="list-style-type: none"> • 0.0675kg/hive by \$520/kg = \$35.10 	\$520/kg

6. Viability of an Australian royal jelly producing industry

The preliminary cost analysis has shown that the breakeven farm-gate price for Australian produced royal jelly may be as high as \$520/kg. This price is substantially higher than the Australian retail price for Chinese produced royal jelly i.e. \$296.16 (see Table 4.1).

While a premium might be anticipated for Australian produced and certified royal jelly the market is known to be price sensitive and it is unlikely that Australian produced royal jelly will find a buyer at \$520/kg.

Nevertheless there are a number of innovations in addition to the Bao Chun Royal Jelly Machine that may, in the longer term, work in favour of a lower Australian royal jelly production cost:

- Superior genetics – lifting average per cell royal jelly output from 0.3 grams per queen cell achieved in Europe to 1.0 gram achieved in China. A productivity gain of this magnitude would reduce the breakeven price that beekeepers would need to receive from \$520/kg to \$150/kg. These genetics might be imported from China (quarantine laws permitting) or developed in Australia from honey bee stock selectively breed for royal jelly production
- Colony manipulation - use of ultra-strong multi queen colonies. The Chinese have found that multiple queens will live harmoniously in a single hive if a mandible is removed from each queen so that a second queen cannot be clasped and stung to death. An ultra-strong multiple queen hive will have more capacity to mother queen cells and increase the productivity of royal jelly production
- Hive innovation - ‘queen draws’ seen in China are used to quickly introduce queen cells grafted with day old larvae into a colony and remove the same royal jelly filled cells three days later. ‘Queen draws’ may further reduce royal jelly labour requirements already minimised by production using the Bao Chun Royal Jelly Machine. A ‘queen draw’ is shown in Figure 6.1.

Figure 6.1 – ‘Queen Draw’: Chinese innovation for rapid insertion and removal of rows of queen cells used in royal jelly production



Photo credit: Trevor Monson June 2013

A strengths, weaknesses, opportunities and threats (SWOT) analysis of establishing a royal jelly industry in Australia is shown in Table 6.1.

Table 6.1 Australian Royal Jelly SWOT Analysis

Strengths	<ul style="list-style-type: none"> • Established and innovative honey bee industry • Beekeepers who have expressed an interest in royal jelly production • Access to new technology which will reduce the amount of labour required to produce royal jelly in Australia • Expanding market for royal jelly in health supplements and cosmetics both in Australia and overseas • Low levels of pesticides and antibiotics used in Australian beekeeping industry provides basis for claiming a ‘clean’ product e.g. no use of arachnicides for Varroa control
Weaknesses	<ul style="list-style-type: none"> • Current breakeven cost at the farm-gate is greater than the retail price of Chinese alternatives • The Bao Chun Royal Jelly Machine is still a prototype without a history of successful commercial use • Even with new technology production is still labour intensive and Chinese royal jelly is competitively priced. • Historically, labelling laws have allowed Chinese royal jelly manufactured into products in Australia to be labelled “Made in Australia” (law amended 2016) • Australian honey bees have not been selectively bred for royal jelly production and production per cell is significantly less than in China
Opportunities	<ul style="list-style-type: none"> • China has demonstrated a willingness to pay a premium for genuine Australian health supplements and royal jelly may be consistent with this trend • Countries such as Switzerland are working toward defining a national standard for royal jelly (Sabatini <i>et al</i> 2009) and this may work in favour of a high quality certified Australian product and against adulterated ‘fakes’ • Europe has banned the importation of royal jelly from China and other places where it cannot be certified and this has boosted both the local European supply and the opportunity for ‘clean’ Australian imports
Threats	<ul style="list-style-type: none"> • There is an abundance of fake Australian royal jelly in China which may undermine development of a genuine Australian product • China will also adopt the Bao Chun Royal Jelly Machine further lowering that country’s cost of supply • Selling a commodity in China with few other outlets (possibly Japan) may result in downward pressure on price over time • Royal jelly is clinically unproven as a health supplement • Some people are allergic to royal jelly and a health scare may disrupt market development

There are substantial risks associated with establishment of an Australian royal jelly industry and further research is required on Chinese buyer willingness to pay and the effectiveness of prototype Bao Chun Royal Jelly production equipment.

7. Study conclusions and recommendations

The study has shown that there is a market for Australian produced royal jelly of approximately 173,750 kg per annum. Sales would be dominated by exports to China and Japan. Unfortunately even with the use of new labour saving technology cost of production remains significantly higher than product supplied out of China – an Australian farm gate cost of \$500/kg compared to a retail price for Chinese produced royal jelly of \$296.16/kg. In addition to the labour saving technology evaluated in this study there are a number of other innovations that may, in the longer term, work in favour of a lower Australian royal jelly production cost. These include superior genetics, colony manipulation and innovative hive technology.

This study recommends that RIRDC give consideration to the funding of a small trial using the Bao Chun Royal Jelly Machine to confirm cost of production estimates used in this report.

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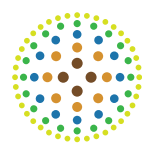


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