Australasian Agribusiness Review
2020, Volume 28, Paper 2
ISSN: 1883-5675

The Australian Apple Industry – Trends and Challenges[1]

Sarah Rohr, Stuart Mounter, Euan Fleming and Garry Griffith

Respectively, PhD student, Associate Professor, Emeritus Professor and Adjunct Professor, Centre for Agribusiness, UNE Business School, University of New England, Armidale.

Abstract

Apples are an important and popular fruit among the Australian population and, in the case of fresh apples, the domestic market is relatively self-sufficient. Retail specifications and consumer preferences are the driving force for quality standards for apples along the chain, with actors working to provide the best quality selection of produce. However, the industry is facing many inter-related challenges. These include the growing influence of climate change, the changing nature of consumer preferences, an increasing shortage of labour to undertake orchard operations, and a significant volume of loss and waste. These challenges are discussed in this paper. While all of these challenges are important, it is noteworthy that the total amount of fresh apples that is potentially diverted from the Australian fresh apple supply chain each year is conservatively estimated at 163,000 tonnes, about 40 per cent of total production at the farm level. If this waste is valued at the average farm price, it equates to an industry loss of $245 million annually.

Keywords: apple industry, food loss and waste, climate change, labour shortages, policy options

Part 1: Trends in the Australian Apple Industry

Introduction

Worth over $511 million in 2016/2017, the Australian apple industry was the third most valuable fruit industry in Australia (excluding grapes) according to ABS (2018). Despite an overall production increase in the Australian fruit and nut industry, there has been a slight decline in the production of apples in the last few years, although apples were still purchased by 91 per cent of Australian households in 2018 (Hort Innovation, 2019). The apple industry has fallen from the most valuable fruit industry to third behind bananas and almonds in 2018 (ABS, 2018). Of Australia's total apple production in 2018, 29 per cent was sent to processing (Hort Innovation, 2019) with the remaining 71 per cent supplied to the fresh apple value chain. Australia is a small net exporter of fresh apples (Hort Innovation, 2019), with just over 5,060t exported in 2019 and only 1,145t imported, with imports divided fairly equally between China and New Zealand. The processed apple industry comprising dried products and juices is more dependent on imports. In 2018, import and export values of juice were $38.2 million and $4.0 million, respectively, while dried apple imports and exports were worth $4.4 million and $0.68 million, respectively (Hort Innovation, 2019). Although

[1] An earlier version of some of this material was presented at the 14th Systems Dynamics and Innovation in Food Networks Forum, Garmisch, Germany, 10-14 February 2020.

processing is a significant sector of the Australian apple industry, the focus of this analysis is the Australian fresh apple value chain.

Apple Production

The lead time of an apple tree from crop planting to commercial harvest is between four and five years. According to ABS (2018), there were more than eleven and a half million apple trees of fruit-bearing age in 2016/2017 that produced an average yield of 26.9 kg of fruit per tree (Table 1).

Table 1. Australian Apple Yield Data, 2016/2017

Commodity description	**Estimate**
Fruit and nuts - Pome fruit - Apples - Total trees (no.)	13,166,709
Fruit and nuts - Pome fruit - Apples - Trees not yet of bearing age (no.)	1,521,446
Fruit and nuts - Pome fruit - Apples - Trees of bearing age (no.)	11,645,263
Fruit and nuts - Pome fruit - Apples - Production (kg)	313,730,397
Fruit and nuts - Pome fruit - Apples - Yield (kg/tree)	26.9

Source: Australian Bureau of Statistics (2018)

Domestically produced apples are available for consumption year-round, made possible by storage of fresh apples in controlled atmosphere conditions, with availability the highest in March/April for New South Wales, Victoria and Tasmania and slightly later, April/May, for Queensland, Western Australia and South Australia (Hort Innovation, 2019). The domestic fresh apple market is dominated by three varieties: Pink Lady, 41 per cent of available apples; Gala, 23 per cent; and Granny Smith, 18 per cent. The remaining 18 per cent is comprised of numerous other, minor varieties (Hort Innovation, 2019).

On average it costs between $400 and $450 per tonne to produce apples. Farmers aim to sell as much of their harvest as possible to the fresh market to receive the highest price[2]. Although national data suggest that almost one third of apple production is sent for processing, one industry source quoted a much lower proportion at an average of seven to ten per cent of their producers' harvests[3]. It was noted that some producers pay their pickers to leave lower quality apples on the tree as the additional costs in handling and storage are not covered by the processing market price. The Australian 'apple year' ranges from April to March and most producers aim to have most of their harvest (around 75 per cent) sold by October, to account for reduced demand in the summer months due to consumer preferences for more exotic fruits[4]. Overall domestic apple farm-gate production, prices and aggregate values for the last three years, are listed in Table 2.

Apples are grown in all Australian states (Figure 1); however, almost half are grown in Victoria (Hort Innovation, 2019). The major apple producing areas within each state are:

- Victoria: Goulburn Valley, Gippsland, and Yarra Valley
- New South Wales: Batlow and Orange
- Queensland: Stanthorpe
- South Australia: Adelaide Hills region
- Tasmania: the Huon Valley and the North Western region

[2] Interview with Australian apple grower who wished to remain anonymous, October 17, 2019.
[3] Interview with General Manager of Producer Organisation who wished to remain anonymous, October 12, 2019.
[4] Interview with Australian apple grower who wished to remain anonymous, October 17, 2019.

- Western Australia: Donnybrook and Manjimup

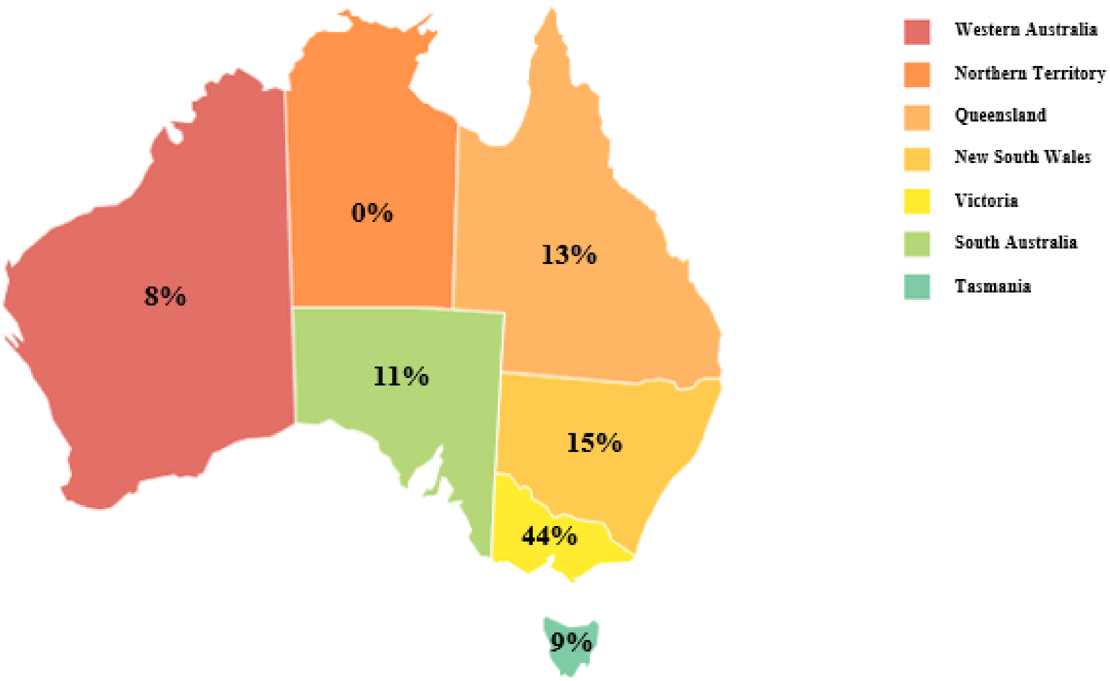
Table 2. Total Australian Apple Production, Value and Prices, 2016-2018

	Years Ending		
	2016	**2017**	**2018**
Production (t)	316,758	319,686	315,185
Value ($m)	441.50	497.20	465.30
Price ($/kg)	1.39	1.56	1.48

Source of data: Hort Innovation (2019), *Australian Horticulture Statistics Handbook*

These apple-producing regions are mapped in Figure 2 to demonstrate the spatial variation among these areas. Although different geographically, the climatic conditions exhibit similarity with typically mild temperatures throughout summers, cool autumns and cold winters. To ensure water requirements are fulfilled, reliable access to water for irrigation is needed in some regions. Specificity of exact climate conditions can differ among varieties; however, a general guideline for the trees to break dormancy is 500-650 hours below 7ºC (AgriFutures, 2017).

Figure 1. Australian Apple Production by State*, 2019



*Australian Capital Territory is not identified independently, and is included within New South Wales production. Northern Territory production is negligible. *Source:* Adapted data from Hort Innovation (2019)

Imports and Exports

While domestic production accounts for almost all of the fresh apple supply in the domestic market, there are some small-scale import and export activities (Table 3 and Table 4). Export apples receive a higher unit price than fresh apples for the domestic market, due to the additional marketing inputs that are required to make the fruit available for export. Similarly, the price per kg of imported apples also exceeds the domestic price per kilogram (Hort Innovation, 2019) due to higher costs. While imports of fresh apples are relatively low, they are available to the market in limited quantities during the Australian "off-season", from August through to March.

Figure 2. Australian Apple Growing Regions

Source: Hort Innovation (2019)

Table 3. Australian Apple Exports, 2016-2018

	Years		
	2016	**2017**	**2018**
Fresh Export Volume (t)	4,665	4,950	5,060
Fresh Export Value ($m)	12.40	12.70	11.30
Fresh Export Price ($/kg)	2.66	2.57	2.23

Source of data: Hort Innovation (2019), *Australian Horticulture Statistics Handbook*

Table 4. Australian Apple Imports, 2016-2018

	Years		
	2016	**2017**	**2018**
Fresh Import Volume (t)	619	1,053	1,145
Fresh Import Value ($m)	1.60	2.40	2.90
Fresh Import Price ($/kg)	2.58	2.28	2.53

Source of data: Hort Innovation (2019), *Australian Horticulture Statistics Handbook*

Processing

The annual processing volumes from the past three years are shown in Table 5.

Table 5. Australian Domestic Apple Processing, 2016-2018

	Years		
	2016	**2017**	**2018**
Processing (t)	92,901	92,555	92,156

Source of data: Hort Innovation (2019), *Australian Horticulture Statistics Handbook*

Anecdotal information from one industry source indicated that producers aim for 10 per cent or less of apple production sales to the processing sector[5]. These figures were corroborated by another organisation within the industry who indicated that approximately 70 per cent of the collected harvest was marketed to retail as first grade apples, around 20 per cent was marketed as second grade and the remaining 10 per cent was sent for processing[6,7]. The prices paid by processors depend on the final product end use (as there are different standards for the type of processing such as slices for baking, puree, cider and juicing) and fluctuate depending on demand and seasons. A conservative average price paid for processing apples is around $300 to $350 per tonne ($0.30 to $0.35 per kg); however, this may increase to $700 per tonne in peak times[3]. This $300 to $350 per tonne range is lower than the average cost of production ($400 to $450 per tonne) and is a potential driver of apple waste.

Fresh Supply/Wholesale

Hort Innovation believes the Australian fresh supply of apples to be determined as follows.

Fresh supply = production – exports – processing + imports

Notionally, this is the supply of fresh apples inclusive of any loss or waste. Based on Hort Innovation's formula, the fresh supply of apples net of processing and trade is shown in Table 6 for the years 2016-2018. On average, the fresh/wholesale supply accounts for approximately 70 per cent of the total domestic production.

Table 6. Australian Wholesale Apple Supply, 2016-2018

	Years		
	2016	**2017**	**2018**
Fresh Supply (t)	219,811	223,234	219,115
Fresh Wholesale Value ($m)	490.20	554.50	519.50
Wholesale Price ($/kg)	2.23	2.48	2.37
Fresh Supply per Capita (kg)	9.12	9.11	8.79

Source of data: Hort Innovation (2019), *Australian Horticulture Statistics Handbook*

While these figures are indicative of fresh wholesale supply, it is important to note that a small proportion may be sold direct from the farm to the consumer, bypassing conventional wholesale

[5] Interview with Australian apple grower who wished to remain anonymous, October 17, 2019.
[6] Interview with General Manager of Producer Organisation who wished to remain anonymous, October 12, 2019.
[7] Some apples are produced solely for processing, however estimates are not available.

trade. Direct sale options, including those at the farm gate, markets and food service providers, have little regulation of standards and minimal cost to market; however, these volumes are typically small and there is more work required for self-marketing and distribution. Conventional marketing options for producers are typically through cooperatives, agents or grower organisations. There are currently two apple cooperatives in Australia: one in South Australia and one in the Orange region of New South Wales. Grower organisations are something of an adapted cooperative: one primary organisation has an ownership component that is not exclusive to members and which adheres to a corporate structure[8]. The cooperatives and grower organisations provide the storage, packing and marketing services that otherwise would be provided by a wholesaler or trader. The exact number of apple producer organisations and wholesale traders varies as they frequently trade a range of fruits and may or may not trade apples at a given time. The sale of fruits from the intermediaries (cooperatives, wholesale traders or grower organisation) to the dominant supermarkets is typically done through contracts under the provision of the supermarket standards for the apples (AgriFutures, 2017).

The Australian Fresh Apple Retail Market

There are several avenues through which fresh apples can be marketed. The five main distribution channels are: direct sales from farms to supermarkets; sales from farms to processors; sales to restaurants and food service organisations; direct sales to consumers at farm gate or farmers markets; and sales through wholesale or export markets.

There are a range of factors which affect the choice of any selling method and the pathway to the consumer. Sales directly to supermarkets are often in sizeable quantities; however, market access can be quite difficult and openings limited. Spencer and Kneebone (2012) noted that approximately 17 per cent of fruit and vegetables in Australia are transferred to the food service market and 83 per cent are directed to retail outlets, including supermarkets and specialty stores. Based on Spencer and Kneebone's estimates, the split of fresh apple wholesale supply for the years 2016-2018 is shown in Table 7.

Table 7. Australian Apple Destinations from Wholesale, 2016-2018

	Years		
	2016	**2017**	**2018**
Retail (t)	182,443	185,284	181,865
Food Service (t)	37,368	37,950	37,250

Source of data: Adapted from Hort Innovation (2019), *Australian Horticulture Statistics Handbook* and Spencer and Kneebone (2012)

Estimates of purchases from retail outlets (Harvest to Home, 2019) include major supermarkets, other supermarkets and other specialty stores. Over the years 2017 and 2018, 77 per cent of apple purchases were bought at major supermarkets, 7.7 per cent were bought at other supermarkets and 15.3 per cent were obtained at non-supermarkets such as specialty stores and grocers. These household purchase data are presented in Table 8. Although these data are only available for the past two years, it provides an insight into the quantities of fresh apples purchased by Australian households and the average retail prices paid. The average purchase price per kilogram was calculated as average annual purchases ($) divided by the average annual weight purchased (kg). The total amount purchased in 2017 and 2018 equates to around 66 per cent and 68 per cent

[8] Interview with General Manager of Producer Organisation who wished to remain anonymous, October 12, 2019.

respectively of the estimated amounts available to retail as derived from the fresh supply. Given the significant difference in the volume available for retail and the recorded purchase data, it can be assumed that substantial waste occurs along the value chain, specifically between the retail and consumer stages.

Table 8. Australian Fresh Apple Retail Household Purchases, 2016-2018

		Years
	2017	**2018**
Total Retail Volume Purchased* (t)	125,875.2	120,268.8
Average Annual Purchases ($)	47.70	50.70
Average Annual Weight Purchased per Household (kg)	14.90	14
Average Annual Weight Purchased per Capita (kg)	5.73	5.54
Purchased $/kg	3.20	3.52

* Based on projected number of households. *Source of data*: Harvest To Home (2019)

There are no recent consumption data for apples. Levy data from the Department of Agriculture and Water Resources (cited by Apple and Pear Australia Ltd, 2019a) indicate that annual per capita consumption in 2014/2015 was 7.98kg. This is higher than the most recent per capita purchase data; however, per capita apple consumption declined from 2012 to 2015 (Apple and Pear Australia Ltd, 2019a). If this decrease in apple consumption has continued, then the recent purchase data may be a reasonable approximation to current consumption.

The Australian fresh apple value chain is illustrated in Figure 3. Data provided are annual averages calculated for the three-year period 2016-2018[9].

Part 2: Challenges Facing the Australian Apple Industry

Loss and Waste

Food losses and waste occur throughout all food value chains; however, losses of edible fruits and vegetables are amongst the highest for all food groups (Laurentiis et al., 2018). Gustavsson et al. (2011) stated that over 50 per cent of edible fruits and vegetables are removed from the entire value chain in the North America and Oceania region (including Australia). Most of these losses occur pre-farm gate and at the consumer level, with smaller amounts of loss and waste occurring at the post-harvest, processing and distribution stages.

Rohr et al. (2020) reviewed the available literature in Australia and elsewhere and provided estimates of the potential volume of loss and waste in the Australian apple industry. Apart from that already mentioned, the literature reviewed included Baker, Gray et al. (2019), Gooch et al. (2019), WRAP (2013), RMIT (2016), Australian Government (2017, as cited by ARCADIS, 2019, pp. 56), and Buzby et al. (2014). Estimates of potential loss and waste in the Australian fresh apple value chain are shown in Figure 4, by applying the estimated percentages and definitions from Gustavsson et al. (2011), as shown in Table 9. Rohr et al. (2020) also examined the main drivers of apple industry loss and waste, and some of the externalities arising from this.

[9] The quantities displayed in Figure 3 show some discrepancies between the various stages of the value chain, with not all apples accounted for. The most significant discrepancy is between retail availability and consumer purchases. As these quantities are averaged from the abovementioned data sets as well as across time, it is assumed that the discrepancies represent food loss and waste along the value chain.

Figure 3. The Australian Fresh Apple Value Chain, 2016-2018 Averages

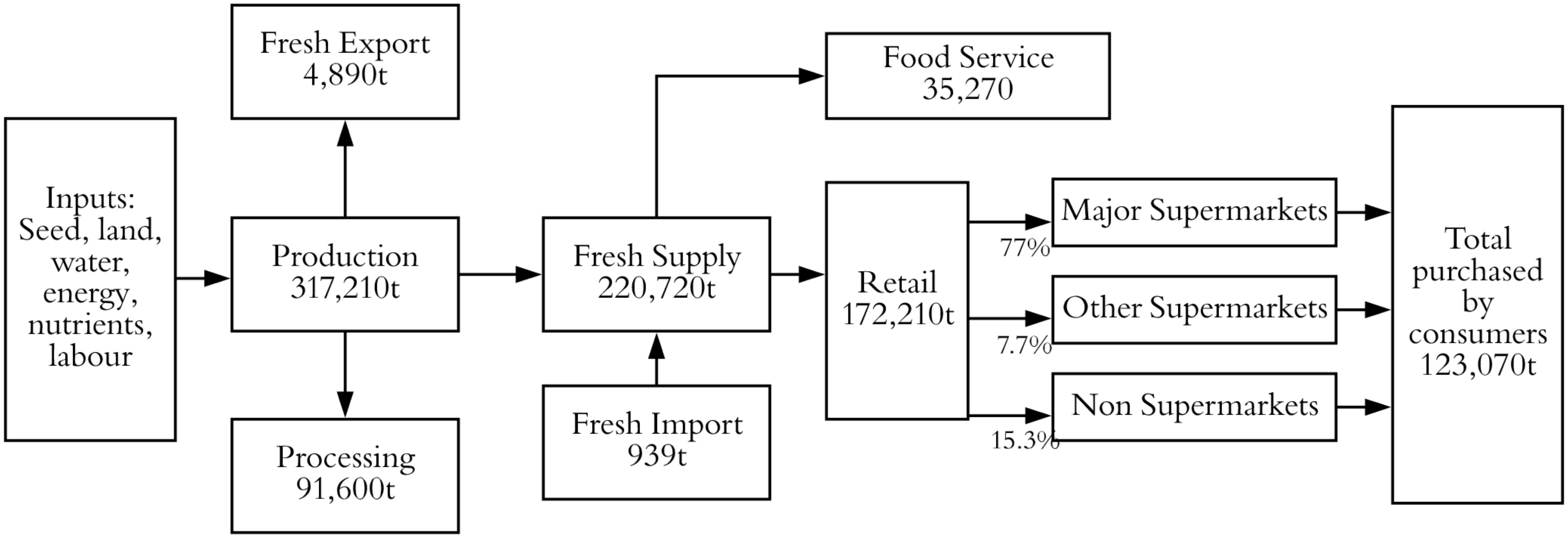


Table 9. Estimated/Assumed Fruit and Vegetable Loss and Waste

Agricultural Production	20 per cent
Postharvest handling and storage	4 per cent
Processing and packaging	2 per cent
Distribution: Supermarket Retail	12 per cent
Consumption at home	28 per cent

Although generalised across all fruits and vegetables, applying the Gustavsson et al. (2011) percentages for loss and waste provides a consistent way of making the estimates, which can then be compared with the individual estimates from other studies which apply to single stages of the chain. For example, applying the Gustavsson et al. (2011) loss value of 20 per cent prior to farm gate to the official Australian production data, 317,210t, it can be interpreted that the 317,210t of apples officially recorded represents only 80 per cent of total fruit originally produced. Thus, 396,513t were actually produced but 79,303t were lost on the farm.

The total amount of fresh apples, conservatively, that is potentially diverted from the Australian fresh apple supply chain is over 163,000t which is around 41 per cent of total production at the farm level. This estimate is not inconsistent with reports by Gustavsson et al. (2011) that over 50 per cent of fresh fruit and vegetables are lost or wasted. It should be noted that this does not necessarily represent the amount that ends up in landfill, as losses and wastes may be diverted to compost, animal feed or donated. When there were multiple waste values referenced, the more conservative estimate was applied. However, loss and waste of this magnitude will incur substantial costs to manage and has potentially significant environmental implications.

Climate Change

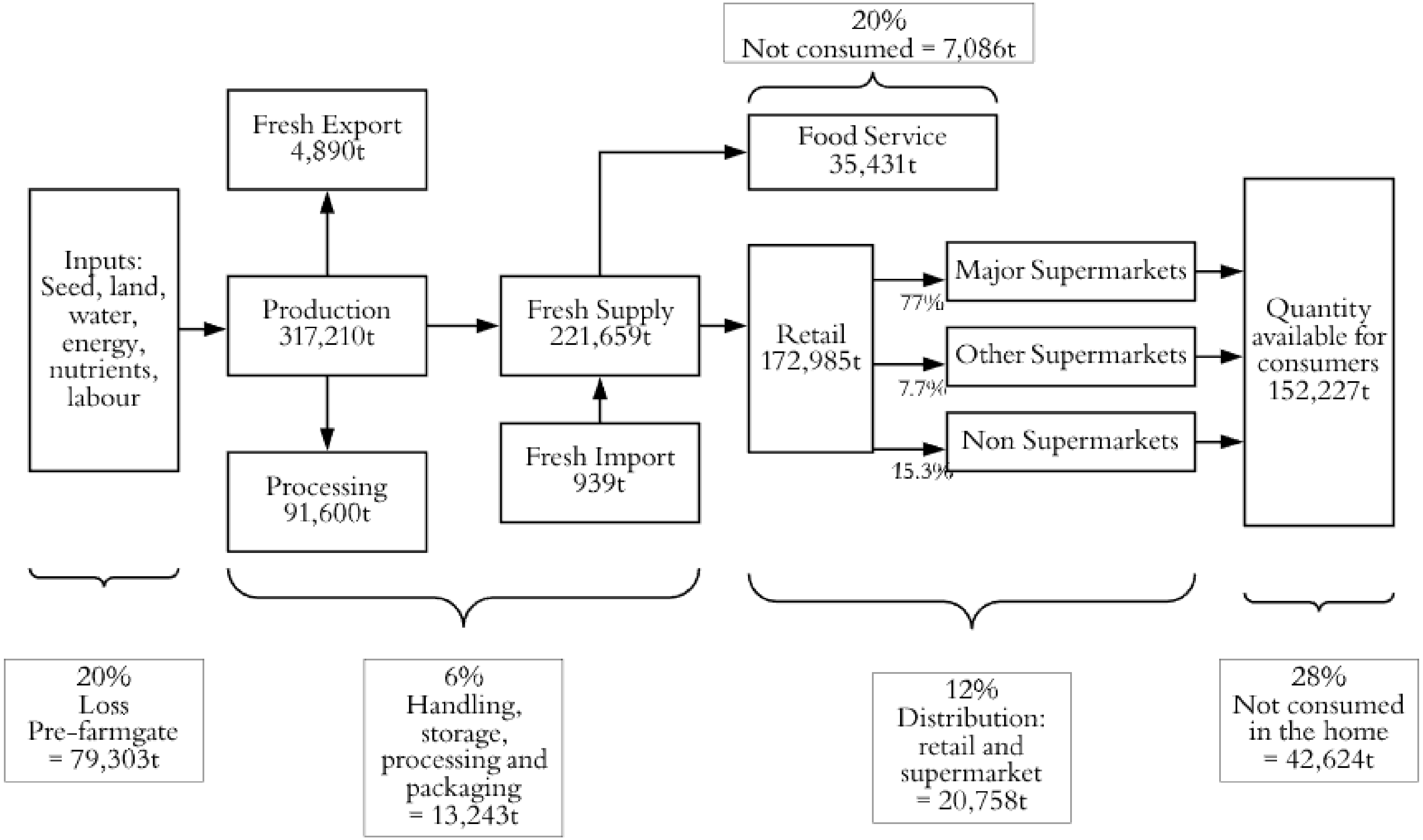
The impacts of greenhouse gas emissions and the associated issues of climate change directly and indirectly affect the production of fresh fruits (Moretti et al., 2010). Changed climatic conditions include increased temperatures, elevated carbon dioxide levels and ozone exposure. Impacts on fruit quality include alterations to firmness of the fruit, sugars and flavonoid contents, all of which are quality parameters of fresh apples (Moretti et al., 2010). Australia is currently experiencing, and will likely experience more so in the future:

- Higher temperatures (especially overnight and winter), and longer periods of extreme heat,
- More variable rainfall, and more extreme and longer periods of "official" drought,
- More volatile storm activity, with more hail, more intense rainfall and higher winds, and
- More intense and more widespread bushfires, plus associated smoke and ash taint.

All of these factors reduce the yield and quality of fruit in horticultural industries and contribute to loss and waste, unless effective adaptation measures are implemented.

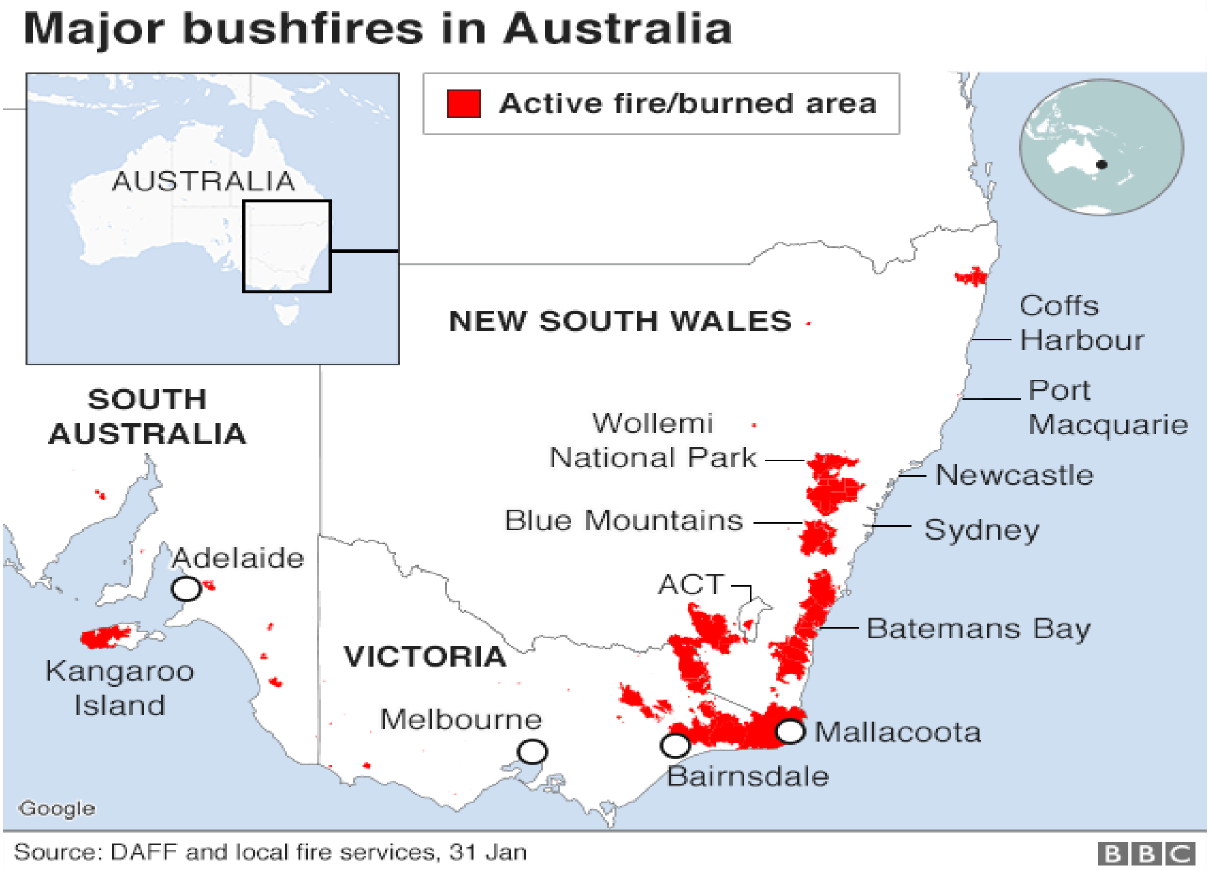
All of these climate factors have been strikingly evident in south-east Australia during the recent past. Jones (2018) reports that severe hail storms hit the Adelaide Hills apple orchards in late 2018 for the second year in succession: "The storms brought hail and widespread power outages to apple crops in Uraidla, Forest Range, Lenswood, Balhannah and Oakbank, just as the new season's fruit was forming." (p.1).

Figure 4. Estimates of Food Loss and Waste across the Australian Fresh Apple Value Chain[10]



[10] Illustrates Gustavsson et al.'s (2011) rates of food loss and waste of fresh produce in the Oceania region applied to the Australian apple value chain. They do not equate to the assumed loss and waste amounts from the discrepancies between the value chain stages.

Figure 5. Major Bushfires, Australia, at 31 January 2020



Another particularly damaging event for the apple industry was the 2019/2020 bushfire season. Comparing Figure 2 with the fire map shown in Figure 5 above indicates that many of the regions destroyed by the fires were apple growing regions (Batlow, Gippsland and the Adelaide Hills in particular). Not shown in Figure 5 but also impacted earlier was the region around Stanthorpe in southern Queensland.

Apple and Pear Australia Ltd (2020a) estimate that more than $70 million of damage was caused by the December/January fires, with the worst affected region being Batlow. Lowrey (2020) notes the length of time required to re-establish burnt orchards, with local growers in Batlow estimating it will take eight years before they are back in full production.

Labour Shortages

"Labour is a major input and one of the main costs of horticultural businesses supplying the fresh fruit market. Harvesting apples and pears requires labour to hand-pick the fruit, because of susceptibility to bruising. Picking is done in the relatively short times when quality is optimum. Labour is also required for pruning and thinning trees." (Sinnert et al., 2020, p.1).

The labour requirements of three case study apple orchards in Victoria are described in Table 10. Many of these jobs are filled by backpackers (tourists), and in recent years there have been widely reported incidents of backpacker mistreatment, underpayment, and OHS issues (The Guardian, 2019). It was suggested that this publicity has reduced the supply of this type of labour, so grower demand for labour has not always been met. The fact that most apple growing regions are well away from the capital cities is also a factor. This has been compounded by recent tightening of Government immigration policies, making it harder for willing workers to get temporary work visas, and will be compounded further by Covid-19 travel-related restrictions.

Table 10. Labour Requirements of Three Case Study Apple Orchards

Case study 1 (70 ha pome fruit)	Case study 2 (26 ha apple orchard)	Case study 3 (135 ha apple and pear orchard)
9 Full timers (paid an hourly rate). 16-18 contractors (paid an hourly rate, except at harvest, some prefer to be paid pieceworker rate). 20 backpackers (paid pieceworker rate).	3 Full timers. Up to 17 casuals at various times (all paid an hourly rate).	On average across the year 60 people are employed to work on the orchard. 3 Full timers and casuals at various times (all paid an hourly rate).

Source: Sinnert et al. (2020)

Not only are labour requirements high, labour costs are high. The award rates range from around $18/hour up to $26/hour for skilled casual workers. The high costs of picking sometimes lead to poor quality fruit being left on the trees, adding to loss and waste.

Consumer Preferences

Supermarkets are the primary drivers of the quality of apples at the retail level, and the early stages of the value chain strive to provide the required grades and quantities. The standards are typically around aesthetic qualities, such as size, shape and colour as well as firmness and mineral content. Apples that meet very tight specifications achieve premium prices, but apples that are unsatisfactory in quality are discounted heavily or wasted. Thus, the retail standards, either real or perceived, can be contributing factors to food loss and waste (Minor et al., 2019). Retailers are unlikely to accept fruit that consumers are unwilling to eat or purchase as the burden of unsalable food incurs additional costs and resources (Minor et al., 2019). Retailer stock holding and pricing policies also have an influence on what is offered to consumers and what is wasted (Baker, Popat et al., 2019)

Huey et al. (2018) reviewed the literature surrounding apple eating quality and concluded that there was little correlation between consumer perceptions of quality and actual eating quality of apples. The industry recognises that inconsistency in delivering good eating experiences are inhibiting industry profitability (Horticulture Innovation Australia, 2017). Further, additional food waste also occurs once consumers take the apples home. Poor eating experiences could contribute to this by causing consumers to discard fruit.

The greater availability of substitute fruits, often imported, means that eating quality of apples has become even more important in recent years.

Consistent eating quality can be achieved through coordination of the supply chain processes that align factors that affect the eating quality of apples (ripeness). Alignment of harvest maturity, storage periods and supermarkets' marketing windows is required for improving the quality reputation of the apple.

Value Chain Responses

Crop protection

To mitigate the effects of changing climatic conditions, netting of orchards is employed to reduce the extent of hail damage to apples, reduce sun-damage (Whitaker and Middleton, 1999) and reduce damage from pests (Middleton and McWaters, 2002). During typical sun-damage temperatures, McCaskill et al. (2016) identified that netting reduced the surface temperature of apples by an average of 1.5-2.0°C. Netting not only intersects the solar beam, it also allows sufficient air circulation to assist in reducing the fruit's surface temperature and preserving the quality of the fruit.

Table 11. Apple Quality, in Open Orchards and Under Hail Netting

Fruit quality (sunburn incidence as % of fruit numbers) in the open and under hail netting.

	1996 Hi Early (NSW)		1997 Granny Smith (Vic)		1998 Red Fuji (Qld)	
Sunburn	**Open**	**Net**	**Open**	**Net**	**Open**	**Net**
Severe			9.2	0.8		
Moderate + severe	7.8	0.7	21.1	6.4	36.0	8.0
Sample size	**(8,000 apples)**		**(13,000 apples)**		**(11,200 apples)**	

Source: Middleton and McWaters (2002)

Although dated, the data in Table 11 highlight the significant difference in quality of netted and un-netted fruit (at minimum, a 75 per cent reduction in damage). With ever-increasing concerns of rising temperature trends and climate change, employing proven quality management strategies is imperative to delivering the best fruit throughout the chain. Netting not only reduces environmental damage, it protects fruit from damage by pests (such as birds and bats), and the colour of netting used can also impact the size and production levels of the fruit (Kerr, 2015). Quality improvement strategies such as netting have the potential to also reduce on-farm and pack-house level losses as the amount of damaged fruit is reduced when compared to non-netted crops. If the quality of fruit is improved from the farm level, there is potential for additional value to be obtained along the chain, in addition to a reduction in the cost of managing food loss and the associated externalities.

Given the advantages of netting, there has been a push for local and state governments to assist in making the process feasible more widely. South Australia required permits for netting to be erected. The requirement for permits has since been removed, yet there are continued regulations that add complexity to the process (Kerr, 2015). In other states, implementation is assisted by the state government, albeit for various objectives. In New South Wales, the government subsidises 50 per cent of the cost of the netting to address damage by flying foxes, reducing some of the financial constraints that may prevent the uptake of netting (Kerr, 2015).

Technology

Incorporation of technology and value adding initiatives by growers have proven fruitful. A case is the Ceravolo family, who have now centralised all logistics and infrastructure on their farm in Ashton in South Australia (Hudson, 2016). Their use of technology such as hanging probes, netting and wearable scanners has increased the amount of information available about their harvest, ensuring they can meet their high-quality fresh standards. The increased data availability enhances their vertically integrated chain, which is controlled from farm to direct delivery to major supermarkets and the nearby Adelaide wholesale markets (Hudson, 2016). Their operations also expand to their on-site juicing, making use of the apples that would otherwise be marketed as "seconds" or wasted, and maintaining prices for their top-graded apples. The value of their juicing operations is increased with facilities that allow visitors to observe the end-to-end processing and enjoy the finished product in their range of dining facilities (Apple and Pear Australia Ltd, 2017).

With labour shortfalls impacting the Australian apple industry at the early stages of the value chain, research and development in the harvesting process has significant potential to improve harvest efficiency (Zhang et al., 2019). Typically, apples have been harvested manually by workers using ladders and buckets, moving along rows in the orchard while moving up and down the ladder to pick high and low apples. Assessing the efficiency of pickers over time, Zhang et al. (2019) identified that only 76 per cent of the allocated time was spent picking apples, including reaching, picking and transporting the apples. The remaining time was spent moving ladders and buckets and the workers positioning themselves for picking. Not only does manual picking lead to less productive use of time, it also leads to occupational injuries due to the movement and lifting required.

To overcome these issues, Apple and Pear Australia Ltd (2020b) highlighted the potential of methods such as fruiting walls, which also allow the use of robotic harvesters (when available) and picking platforms such as shown in Figure 6. Whilst picking platforms require appropriate configuration of orchards to be implemented, they offer significant improvements in harvest efficiency whilst also reducing the costly labour requirement that can lead to apple loss at the farm level.

Figure 6. Traditional Ladders, Power Ladder and Picking Platform

Source: Sinnert et al. (2020)

Labour Schemes

Implementation of updated harvesting methods is promising but can be costly and may require substantial changes to orchard configuration. To improve both conditions for workers and labour availability, new regulations and programs have been recently introduced (Apple and Pear Australia Ltd, 2019b). Changes have been made to the Horticulture Award rates for casual workers, implementing a minimum two-hour engagement, and there have been updates to immigrant worker programs. These are primarily the Seasonal Worker Program, Working Holidaymakers and the newly introduced Pacific Labour Scheme. Changes to the Seasonal Worker Program and Working Holidaymakers has increased the allowed time workers can stay with, or their ability to return to, employers. The Pacific Labour Scheme increases the availability of workers in rural and regional Australia under continuous employment for up to three years (Apple and Pear Australia Ltd, 2019b). Such labour schemes significantly contribute to the efficiency and productivity of agricultural industries (Brickenstein, 2015).

Marketing Second Grade Apples

A range of initiatives redirect what would be wasted apples to alternative, more useful destinations. These have been developed by actors at numerous stages of the chain, including retailers and industry organisations. Industry organisation Apple and Pear Australia Ltd has promoted the "Hailstone Heros" campaign which originally launched in South Australia (Apple and Pear Australia Ltd, 2018). The campaign highlighted quality and nutritious apples that were suitable for fresh consumption despite minor cosmetic blemishes due to recent hail. This fruit was branded under the Hailstorm Hero name and distributed among retailers including Coles, IGA and ALDI. Another major retailer, Woolworths, also sold the Hailstorm Hero fruit; however, this was categorised in their "Odd Bunch Range" (Apple and Pear Australia Ltd, 2018).

Launched in 2014, the "Odd Bunch" range is an initiative by Woolworths to market fresh produce that may not meet the typical aesthetic standards by retailers. "Odd Bunch" apples are sold in 1kg prepacked bags, with a range of potentially available varieties (Woolworths, 2020). Competitor Coles promotes a similar range of produce under the "I'm Perfect" label, which similarly markets "imperfect produce" in prepacked bags. This range of produce is of acceptable eating quality, but deficient in appearance (often referred to as "ugly" produce) and, hence, would typically be rejected by some actor in the value chain (Calvo-Porral et al., 2017). The utilisation of campaigns such as these not only enables retailers to differentiate themselves and their produce available but also increases awareness of consumers of the taste and quality available in heterogeneous fruit that would otherwise be wasted (Calvo-Porral et al., 2017).

Food Rescue

Of the estimated 48,000 tonnes of food donated to Australian food rescue organisations in 2016/17, fresh produce was a significant amount, accounting for 33 per cent (ARCADIS, 2019). Previously published donation amounts suggested that fruit and vegetables accounted for as much as 73 per cent of donated food product to the Australian foodbank, Secondbite in 2010 (Mason et al., 2011). When Secondbite was not able to use all the produce received, it was forwarded to a pig farmer as livestock feed, saving it from landfill (Mason et al., 2011). Both Coles and Woolworths have direct relationships with food banks and rescue organisations, reducing some of the barriers that may impact the ability to reduce food waste at the retail level. Second in the food waste hierarchy, re-using potential food waste for human consumption is a significant action to reducing food waste while assisting those that are affected by poverty (Papargyropoulou et al., 2014).

In response to challenges to the Australian apple value chain, both private and public organisations have developed initiatives to address and minimise the impact of some of the most pressing issues. Broad industry issues such as labour shortages are addressed by appropriate government departments while the technology and value-added advancements are pursed independently by actors within the chain. All of the initiatives mentioned share the objectives of improving efficiency of production, maintaining high quality apples and consequently minimising losses and waste throughout the chain.

Conclusion

Apples are a significant and popular fruit among the Australian population and, in the case of fresh apples, the domestic market is relatively self-sustaining. Retail and consumer preferences are the driving force of standards for apples along the chain, with actors working to provide the best quality selection of produce for final consumers. However, the industry is facing many inter-related challenges. These include the growing influence of climate change, the changing nature of consumer preferences, an increasing shortage of labour to undertake orchard operations, and a consequent and significant volume of loss and waste.

Globally, loss and waste of fresh produce is amongst the highest of all food groups (Gustavsson et al., 2011) and, from the limited data available, apples appear to be no exception. While there is not accurate and specific data regarding loss and waste of fresh apples in the Australian value chain, reporting of such issues is increasing as is awareness of the greater issues of food loss and waste. There appear to be large discrepancies in estimates of quantities of fresh apples available at the various stages of the value chain (Harvest to Home, 2019, Hort Innovation, 2019), with these discrepancies potentially reflective of loss and waste along the chain. Applying the Gustavsson et al. (2011) estimates of loss and waste to the available Australian data suggests that the total amount of fresh apples that is potentially diverted from the Australian fresh apple supply chain each year is conservatively estimated at 163,000 tonnes, or about 40 per cent of total production at the farm level. If this is valued only at the average farm price it equates to an industry loss of $245 million annually.

This loss and waste is jointly caused by climate events influencing yield and quality on the tree, the availability and high cost of labour to pick the fruit, the requirements of the major retailers to discount fruit which does not meet the high aesthetic standards, and the inventory policies of the retailers which lead to over ordering.

There are several initiatives operating to improve the efficiency of the value chain and to reduce the loss and waste that occurs. Actions to date have primarily been conducted by specific sectors within the industry. However, for greater industry success, actions such as these should be implemented across the value chain through collaboration of chain actors. Collaboration of chain members has the potential for significant economic impact to those directly involved with spillover effects outside of the chain. Proactiveness is required for sustaining the market and the value obtained.

The Australian apple industry requires robust estimates of the volume and cost of this loss and waste to determine the feasibility and appropriateness of intervention strategies (Thyberg and Tonjes, 2015). Further, the costs of food loss and waste extend to environmental and social costs that are external to private market transactions (Beretta et al., 2017). In regard to apples, the most likely externalities are greenhouse gas emissions (GHG) and the use of finite resources as inputs into apple production that are subsequently not fully valued in the market. The management strategies employed to date are responses to private costs only that are incurred at specific parts of the value chain. Maximisation of chain surplus and the internalisation of externalities in the chain is likely to require whole-of-chain collaboration or institutional-based responses (Fleming et al., 2020).

Loss and waste frameworks such as the food waste hierarchy (Papargyropoulou et al., 2014) provide prioritised sustainability strategies for addressing loss and waste, however assessments of cost should accompany decision processes. Thorough evaluation of the costs of both food loss and waste and any consequential externalities is required in addition to the costs and benefits of applying potential mitigation measures. The method of applying such policies must also be explored, whether it be via a government department, individual private actors or a coordinated approach among stakeholders. It should be noted that currently there is little-to-no government involvement driving the management of food loss and waste in the Australian apple value chain.

References

AgriFutures (2017), Apples. Viewed November 21, 2019. Accessed at: https://www.agrifutures.com.au/farm-diversity/apples/

Apple & Pear Australia Ltd. (2017), News. Viewed May 13, 2020. Accessed at: https://Apple and Pear Australia Ltd.org.au/ceravolos-take-hort-awards/

Apple & Pear Australia Ltd. (2018), News. Viewed May 13, 2020. Accessed at: https://Apple and Pear Australia Ltd.org.au/hailstorm-heroes-rise-south-australia/

Apple & Pear Australia Ltd. (2019a), Statistics. Viewed March 22, 2019. Accessed at: https://Apple and Pear Australia Ltd.org.au/industry-info/apple-and-pear-statistics/

Apple & Pear Australia Ltd. (2019b), News. Viewed May 14, 2020. Accessed at: https://Apple and Pear Australia Ltd.org.au/expanded-labour-options-new-laws-too/

Apple & Pear Australia Ltd. (2020a), News. Viewed May 5, 2020. Accessed at: https://Apple and Pear Australia Ltd.org.au/bushfire-recovery-on-the-agenda/

Apple & Pear Australia Ltd. (2020b), News. Viewed May 13, 2020. Accessed at: https://Apple and Pear Australia Ltd.org.au/research-on-harvest-efficiency/

ARCADIS Design & Consultancy (2019), *National Food Waste Baseline: Final assessment report*. Viewed October 11, 2019. Accessed at: https://www.environment.gov.au/protection/waste-resource-recovery/food-waste

Australian Bureau of Statistics (2018), Value of Agricultural Commodities Produced, Australia, 2016-2017. Table 1: Value of Agricultural Commodities Produced- Australia - 2016-17, cat. no. 75030D001_201617, viewed 16 April 2019. Accessed at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7503.02016-17?OpenDocument

Baker, B.A., Gray, L.C., Harwood, M.J., Osland, T.J., Tooley, J.B.C. (2019), "On-farm food loss in northern and central California: Results of field survey measurements", *Resources, Conservation & Recycling* 149, 541-549.

Baker, D., Popat, M., César, A., Griffith, G., Fleming, E., Mounter, S., Godden, D. (2019), Optimality in ordering at retail level – is food cheap enough to throw away? contributed paper presented at the Food Systems Dynamics Forum, Garmisch, Germany, February 18-22.

Beretta, C., Stucki, M., Hellweg, S. (2017), "Environmental impacts and hotspots of food losses: value chain analysis of Swiss food consumption", *Environmental Science and Technology,* 51, 11165-11173.

Brickenstein, C. (2015), "Impact assessment of seasonal labor migration in Australia and New Zealand: A win–win situation?", *Asia and Pacific Migration Journal,* 24(1), "107- 129.

Buzby, J.C., Wells, H.F., Hyman, J. (2014), *The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States*. Washington, D.C., U.S. Department of Agriculture, Economic Research Service, February.

Calvo-Porral, C., Faiña Medín, A., Losada-López, C. (2017), "Can marketing help in tackling food waste?: proposals in developed countries", *Journal of Food Products Marketing,* 23(1), 42 – 60.

Fleming, E., Mounter, S., Griffith, G. (2020), **"**Moving toward sustainable agri-food value chains: challenges and a proposed way forward", *Australasian Agribusiness Perspectives,* Volume 23, Paper 11, 183-196 (in press).

Gooch, M., Bucknell, D., LaPlain, D., Dent, B., Whitehead, P., Felfel, A., Nikkel, L., Maguire, M. (2019), *The Avoidable Crisis of Food Waste: Technical Report*. Ontario, Canada, Value Chain Management International and Second Harvest.

Gustavsson, J., Cederberg, C., Sonesson, U. (2011), *Global Food Losses and Food Waste*. Rome, Food and Agricultural Organisation of the United Nations.

Harvest to Home (2019), Apples Report, 2019. Viewed March 22, 2019. Accessed at: https://www.harvesttohome.net.au/fruitmushroomnuts

Horticulture Innovation Australia (2017), *Apple Pear Strategic Investment Plan*. from http://horticulture.com.au/wp-content/uploads/2017/01/Apple-and-Pear-Draft-StrategicInvestment-Plan-SIP-for-Validation-2017-01-PDF.pdf.

Hort Innovation (2019), *Australian Horticulture Statistics Handbook, Fruit, 2017/18*. Horticulture Innovation Australia Limited. Viewed April 2, 2019. Accessed at: https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/australian-horticulture-statistics-handbook/

Hudson, S. (2016), Ceravolo Orchards: Family apple dynasty a standout. *The Weekly Times,* 2016. Accessed at: weeklytimesnow.com.au/agribusiness/on-farm/ceravolo-orchards-family-apple-dynasty-a-standout/

Huey, Phoebe, Griffith, Garry, Bittner, Evan (2018), "Issues in measuring quality in the Australian apple supply chain", *Australasian Agribusiness Perspectives* Volume 21, Paper 1, 1-23.

Jones, M. (2018), Hail hits Adelaide Hills again. Fruitnet.com, 4 December. Available at: http://www.fruitnet.com/asiafruit/article/177314/hail-hits-adelaide-hills-again

Kerr, F. (2015), *Adelaide Hills Apple Industry Value Chain Analysis, 2015*. Prepared for the Regional Development Australia: Adelaide Hills, Fleurieu and Kangaroo Island, May.

Laurentiis, V.D., Carrado, S., Sala, S. (2018), "Quantifying household waste of fresh fruit and vegetables in the European Union", *Waste Management,* 77, 238–251.

Lowrey, T. (2020), Batlow apple growers have to wait eight years before next crop. ABC news, 9 February. Available at: https://www.abc.net.au/news/2020-02-09/batlow-apple-growers-have-to-wait-eight-years-before-next-crop/11936174

Mason, L., Boyle, T., Fyfe, J., Smith, T., Cordell, D. (2011), *National Food Waste Data Assessment: Final Report*. Prepared for the Department of Sustainability, Environment, Water, Population and Communities. Sydney, Institute for Sustainable Futures, University of Technology, Sydney.

McCaskill, M.R., McClymont. L., Goodwin, I., Green, S., Partington, D.L. (2016), "How hail netting reduces apple fruit surface temperature: A microclimate and modelling study', *Agricultural and Forest Meteorology* Volumes 226–227, 15 October, 148-160.

Middleton, S., McWaters, A. (2002), Hail Netting of Apple Orchards – Australian Experience, Presented at the 45th Annual IDFTA Conference, February 16-20, 2002, Kelowna, British Columbia, Canada.

Minor, T., Hitaj, C., Kuchler, F., Skorbiansky, S.R., Roe, B., Thornsbury, S. (2019), "Exploring food loss from farm-to-retail in the produce industry", *Choices,* 34(1), 1 – 7.

Moretti, C. L., Mattos, L. M., Calbo, A. G., Sargent, S. A. (2010), "Climate changes and potential impacts on postharvest quality of fruit and vegetable crops: A review", *Food Research International*, 43, 1824 – 1832.

Papargyropoulou, E., Lozano, R., Steinberger, J. K., Wright, N., and Ujang, Z, B. (2014), "The food waste hierarchy as a framework for the management of food surplus and food waste", *Journal of Cleaner Production,* 76 (2014), 106 – 115.

RMIT University (2016), Watch My Waste, Interim Data. Viewed April 2, 2019. Accessed at: http://watchmywaste.com.au/

Rohr, S., Mounter, S., Fleming, E., Griffith, G. (2020), Loss and Waste in the Australian Fresh Apple Value Chain, contributed paper presented at the Systems Dynamics and Innovation in Food Networks Forum, Garmisch, Germany, February 10-14.

Sinnett, A., Farquharson, R., Malcolm, B., Ramilan, T. (2020), "A Moveable Harvest: Economic analysis of using mobile platforms for picking apples", *Australian Farm Business Management Journal* Volume 17, Paper 1, 1-20 (in press).

Spencer, S., Kneebone, M. (2012), *FOODmap: An analysis of the Australian food supply chain*. Canberra, Department of Agriculture, Fisheries and Forestry. Accessed at: http://www.agriculture.gov.au/SiteCollectionDocuments/ag-food/food/national-food-plan/submissions-received/foodmap-an-analysis-of-the-australian-food-supply-chain-30-july.pdf

The Guardian (2019), 88 days as a slave – backpackers share stories of farm work exploitation. 26 September. Available at: https://www.theguardian.com/australia-news/2019/sep/26/88daysaslave-backpackers-share-stories-of-farm-work-exploitation

Thyberg, K.L., Tonjes, D.J. (2015), "Drivers of food waste and their implications for sustainable policy development", *Resources, Conservation and Recycling,* 106, 110-123.

Waste and Resources Action Programme (WRAP) (2013), Overview of Waste in the UK Hospitality and Food Service Sector. Viewed April 2, 2019. Accessed at: http://www.wrap.org.uk/content/overview-waste-hospitality-and-food-service-sector

Whitaker, Kristel, Middleton, Simon (1999), The Profitability of Hail Netting in Apple Orchards. Paper presented at the 43rd Annual Conference of the Australian Agricultural and Resource Economics Society. January 20-22, Christchurch, New Zealand.

Woolworths. (2020), The Odd Bunch. Viewed May 13, 2020. Accessed at: https://www.woolworths.com.au/shop/discover/our-brands/the-odd-bunch

Zhang, Z., Wang, Y. J., Zhang, Z. H., Li, D. P., Wu, Z. Z., Bai, R., Meng, G. (2019), "Ergonomic and efficiency analysis of conventional apple harvest process", *Int J Agric & Biol Eng*, 12(2), 210 – 217.