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Circular agri-food approaches: will consumers buy novel products made from vegetable waste?

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ABSTRACT

This article discusses the challenges associated with managing waste in the horticultural sector by presenting the circular economy framework as a solution to the problem of food waste. The research focuses on consumers' role and value adding as one strategy that transforms food waste for reuse in accordance with a circular economy. A structured questionnaire was collected from a sample ($n = 330$) of Australian households to assess consumers' willingness buy food derived from underutilised biomass. The survey found half of the sample was willing to buy value-added food. Helping Australian farmers was the top-ranking factor driving demand. Awareness of the food waste problem is significant in distinguishing consumers who are willing to buy value-added food from those who are not. Marketing recommendations for communication design a circular economy are to stress empathy and care for farmers and highlight the consequences of food waste for both the natural environment and people.

KEYWORDS

Consumer attitudes; circular economy; food waste; valued-added food

Introduction

International momentum to curb food loss and waste is growing, with governments and businesses making commitments to address an issue which has significant ethical, economic, and environmental ramifications for a global society (United Nations, 2016). If food loss and waste were its own country, it would be the third largest greenhouse gas emitter after the United States and China (World Resources Institute, 2015). At the same time, the world's population is forecasted to reach 9.6 billion people by 2050 and sustainably feeding a growing population demands urgent solutions to the food waste problem (World Resources Institute, 2013). Since the Industrial Revolution, economies have followed a model of "take-make-use-dispose" which is called the "linear economy" (Andrews, 2015). The linear economy results in products becoming waste at the end of their life (Figure 1). Many scholars (Andrews, 2015; Lewandowski, 2016; Murray, Skene, & Haynes, 2017) have discussed the linear economy's lack of sustainability and propose alternative concepts that follow nature's life cycles, termed the "circular economy". The circular economy approach is one

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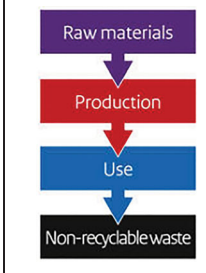
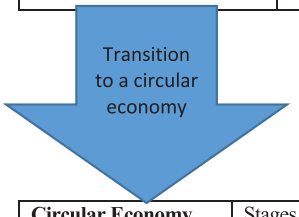
Linear Economy	Linear economy strategy: Disposal	Produce left to rot in fields, going to sewer or landfill





Circular Economy	Stages	Circularity Strategies	Examples
	Production	Avoid or reduce waste	Research for more efficient production methods Cold chain management Packaging initiatives to improve shelf life
	Use	Avoid or reduce waste	Education campaigns Food rescue/charitable donations Aesthetically imperfect food used by different customer groups
	Recycling	Repurpose	Composting, soil enrichers, worm farms Animal feed (for farmed fish, chickens, livestock etc.) and biotechnology solutions for animal feed
		Rethink / reprocess / redesign	Use parts, or all, of discarded product in a new product (cosmetic, pharmaceutical & nutraceuticals) with a different function Use higher quality (high grade) materials & parts of the discarded product in new improved products
		Process / value-add	Use lower quality (low grade) materials for food processing
		Recover	Incineration of food waste (waste-to-energy)

Figure 1. Strategies to move Australian horticulture towards a circular economy. Source: Adapted from Potting, Hekkert, Worrell, and Hanemaaijer (2017) and the National Food Waste Strategy (2017). Image: Government of the Netherlands (https://www.government.nl/topics/circular-economy/from-a-linear-to-a-circular-economy).

response to the problem of food waste and loss. The circular economy represents a closed-loop system in which resources are kept in a loop of production and continuous usage, allowing precious and finite resources to generate more value for a longer period (McDonough & Braungart, 2002). The circular economy involves reuse, repair, refurbishing, and recycling of existing materials and products and what was earlier considered to be waste becomes a resource (Jurgilevich et al., 2016).

In this research, we focus on one circular economy approach, namely value-adding, to deal with the food waste problem in the Australian horticulture industry. In Australia, the horticulture industry is grappling with the food waste challenge, along with climate change

(Fleming, Dowd, Gaillard, Park, & Howden, 2015). Approximately one quarter of all vegetables produced do not leave the farm (Australian Government, 2017), representing a highly inefficient use of resources given that food can be conceptualised as embedded water and energy (Martin & Schouten, 2012). The horticulture industry is a substantial sector of the economy, generating exports worth $2.1 billion (Australian Government, 2016). The agri-food supply chain plays an important socio-economic role in Australia (Pagotto & Halog, 2016) generally and rural economies specifically. In 2012–2013, approximately 56,700 people were employed in Australia to grow fruit, vegetables, and nuts for the domestic and export markets (Department of Agriculture, 2015) and the bulk of this industry is located in regional, and sometimes very remote, places in Australia (Howe, Reilly, van den Broek, & Wright, 2019). Numerous authors highlight waste and inefficiencies in the agri-food supply chain and call for more cooperation amongst stakeholders (Göbel, Langen, Blumenthal, Teitscheid, & Ritter, 2015; Mena, Terry, Williams, & Ellram, 2014) as well as circular economy approaches (Ingrao, Faccilongo, Di Gioia, & Messineo, 2018; Pagotto & Halog, 2016; Secondi, Principato, Ruini, & Guidi, 2019) to enhance sustainable food production systems. Göbel et al. (2015, p. 1440) call for " … regional initiative and model projects for innovative waste management, focused on the re-use of waste and the development of supporting services."

Managing waste in an innovative way is a key factor to more sustainable rural communities (Blades et al., 2017) and also enhances farmers' profits (Chen, Rojas-Downing, Zhong, Saffron, & Liao, 2015). It is argued that tackling food waste and loss would lead to "important opportunities for local economies and stakeholders" (Secondi et al., 2019, p. 10) and "value chain innovation, such as converting horticulture waste into fresh vegetable juices and natural food colors" (Kouwenhoven, Reddy Nalla, & Lossonczy von Losoncz, 2012, p. 132). Curbing food loss may help rural and regional economies and ensure the agri-food sector continues to play a role in the prosperity of people living in rural and regional Australia. One solution to the food waste generated by the Australian horticulture industry is value-adding. Value-adding involves turning fruit and vegetable residues into high value products (Lin et al., 2013) and is one example of the reuse of materials that illustrates circular economy principles (Murray et al., 2017).

In food markets, consumers are the final users. Hence, it is imperative to understand to what extent a circular economy solution to the food waste issue (i.e. novel, value-added food made from food waste) is appealing to food consumers. Studies on the consumer's perspective of a circular economy are lacking (Chamberlin & Boks, 2018), with scholars stating, "little is known about consumers' willingness to participate in a circular economy" (Borrello, Caracciolo, Lombardi, Pascucci, & Cembalo, 2017, p. 1). In the area of value-added food derived from food waste, most existing research is located in the food science discipline and describes restricted examples and pilot-scale laboratory experiences (Mirabella, Castellani, & Sala, 2014). With regard to the consumer's perspective, scholars note consumers are averse to novel, food-related technologies for many reasons, including risk aversion and perceptions of "unnaturalness" (Lusk, Roosen, & Bieberstein, 2014). Branded products derived from food waste are limited and commercialisation (i.e. the process of taking patented products and processes to the market) is challenging (Galanakis, 2012). The present article, by focusing on Australian consumers' attitudes towards novel, value-added products, aims to fill a gap in the literature and also has practical implications for growers and other value chain members.

Literature review & theory

Fruit and vegetables are the second largest commodity contributing to food loss around the world. Food is lost during, or immediately after, harvesting on the farm for several reasons. These include fruit that is bruised, eaten by pests, does not meet the rigid quality standards set by retailers, or is dumped due to over-supply in the marketplace (Lipinski et al., 2013). The two major sources of surplus food and food waste at the farm are overproduction and non-compliance with market standards in terms of size, shape, or appearance (Garrone, Melacini, & Perego, 2014). In Australia, the power of supermarkets to enforce "quality standards" is a source of frustration for farmers (Richards, Lawrence, Loong, & Burch, 2012). It is estimated that 25% of all vegetables produced in Australia do not leave the farm and the total cost of agricultural food loss to farmers is $2.84 billion (Australian Government, 2017). The scale of this loss makes waste reduction, at the pre-and post-harvest stages, an important policy goal, as outlined in the *Food Waste Strategy* (2017).

The vision of a circular economy is gaining traction in academic and practitioner-oriented literatures. There is, however, no commonly accepted definition of a circular economy (Yuan, Bi, & Moriguichi, 2006) and scholars have identified 114 definitions (Kirchherr, Reike, & Hekkert, 2017). The concept of a circular economy, in general terms, promotes resource minimisation (Anderson, 2007) and is most frequently depicted as a combination of reduce, reuse and recycle activities (EU Commission, 2014; Kirchherr et al., 2017; Martin & Schouten, 2012; Woźniak & Pactwa, 2018), which help turn a linear system into a circular system. In a linear economic model, the physical environment is treated as a receptacle for waste products from the economy and design for disassembly, recycling, and reuse are not fundamental parts of the system. This is inefficient since resources (i.e. materials, energy, water, etc.) flow out of the system. A circular economy, on the other hand, is an industrial system that is restorative or regenerative by intention and design. It is founded on the principle of the earth as a closed economic system, where the environment and economy are linked in a circular relationship. The circular nature refers to materials flowing within a closed-loop which are to be reused again and again (Jackson, Lederwasch, & Giurco, 2014). Scholars in the circular economy field often draw upon the waste hierarchy framework (reduce, reuse, recycle, recovery, landfill) and it is agreed that the most important step in the approach to waste management is waste prevention (Papargyropoulou, Lozano, Steinberger, Wright, & bin Ujang, 2014). This research adopts the following definition of a circular economy:

> A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. (Kirchherr et al., 2017, p. 225)

Figure 1 offers examples of how a linear horticultural sector can be turned into a circular system and outlines key strategies. For instance, commodities such as fruit and vegetables are grown, consumed, composted, and returned to the earth to enrich the soil.

Commodities can also be used to make processed food and the materials (i.e. packaging) or waste (i.e. products such as oils, peels, and seeds) can be recycled and returned to the producer or processor and used as inputs in the food industry or another industry.

Currently, Australian horticulture is struggling with food loss and food waste. In general, the term "food loss" refers to food lost in the primary production and processing stages of the value chain and food waste refers to food lost at the retailer, catering, and household levels (Cristóbal, Castellani, Manfredi, & Sala, 2018). The use of food waste should follow waste hierarchy principles with waste prevention (Papargyropoulou et al., 2014), such as consumer education campaigns and donations to charity being the preferred options. Evaluating the relative merits of waste management alternatives, however, is a complex task (Garcia-Garcia et al., 2017). Life cycle analysis shows that some actions (such as consumer education campaigns, cold chain management) should always be prioritised since they avoid a high environmental impact at a low cost (Cristóbal et al., 2018). Food that is edible, but deemed of lower quality in terms of aesthetics, can be sold through local farmers' markets, and there is a rich literature on the benefits of alternative food networks to society (Turner & Hope, 2014). Despite rigid food product standards in mainstream channels, one major Australian retailer, Woolworths, sells some fresh produce at a discount price under the "Odd Bunch" campaign (Calvo-Porral, Medín, & Losada-López, 2017). Food waste can be lightly processed, such as chopped and packaged salads or mixed vegetables, or undergo traditional food processing techniques (i.e. canned, dried, or frozen). These strategies have limitations, however, since the horticultural sector must compete directly with both processed and fresh imports from countries with very low labour rates, which is a challenge in Australia (Queensland Government, n.d.).

Value adding in commodity value chains is increasingly being adopted by growers in reaction to globalisation pressures (Rodríguez Cohard, Sánchez Martínez, & Gallego Simón, 2017). Excess produce can be converted into highly processed products, such as baby food, juices, jams, fermented foods, pickles, sauces, soups, and so forth. In Australia, there is growing interest in waste valorisation practices based on innovative, plant-based products. For example, Natural Evolution Foods is a company that transforms organically grown, green bananas into gluten-free banana flour and starch-resistant dietary fibre (Australian Government, 2017). It is possible to convert food waste into energy, although it is not the most sustainable or cost-effective option for dealing with food waste. Problems relate to the capacity of treatment infrastructure and difficulty in separating food waste from other waste streams (Kibler, Reinhart, Hawkins, Motlagh, & Wright, 2018). Sundrop Farms in South Australia is an example of an innovative, "circular" food producer that grows tomatoes in greenhouses by using solar power, electricity generation, fresh water production, and hydroponics (Sundrop Farms, n.d). Another solution to the food waste problem is to divert it to animal feed. Food waste can be turned into compost which helps "close the loop" in a circular economy (Borrello et al., 2017) and products, such as a liquid to enrich soil health, offer an Australian manufacturing example (BioRegen, n.d.).

Value-adding refers to the process of increasing the value of inputs through transformation, for instance by using manufacturing processes or differentiated production techniques, such as organic production (CSIRO, 2017). For instance, citrus peel can be used as a natural sweetener (i.e. sugar syrup) in processed foods, and pectin can be utilised as a gelling agent by the confectionary sector. In recent times, there has been a move towards "redesign" of commodity products by extracting nutrients from biomass. The

shift towards converting food waste into high-value products is driven by several factors. These include advanced technologies, consumer interest in health, and the sophisticated marketing of functional foods and neutraceuticals by cosmetic and pharmaceutical industries (Ernst, 2001). "Nutraceutical" is a term derived from the words "nutrition" and "pharmaceutical" and can refer to any substance that is a food, or a part of a food, and provides medical or health benefits, including the prevention and treatment of diseases (DeFelice, 1995). Examples include fish oils or olive leaf extract. Likewise, "functional foods" refer to foods that may provide health benefits beyond basic nutrition, such as probiotic drinking yogurt (Siro, Kapolna, Kapolna, & Lugasi, 2008). Food waste is a source of valuable compounds for the pharmaceutical and nutraceutical industries. For instance, bromelain is an enzyme found in pineapple juice and in the stem of the pineapple and can be used to treat medical ailments (Galanakis, 2012; Laufenberg, Kunz, & Nystroem, 2003; Lin et al., 2013; Mirabella et al., 2014). The fresh cut fruit industry discards large percentages of by-products, such as peels, seeds, and unused flesh, that can present similar or even higher contents of bioactive compounds, such as phenolic compounds, carotenoids, and vitamins, than the final product (Mirabella et al., 2014).

Options for waste management in the Australian horticultural sector are a mix of linear and circular economies. Many challenges to reducing food loss exist, including the current nature of food production, with its inherent risks (such as perishability, bad weather, disease, and declined market price), as well as deeply embedded social habits and institutional practices (Canali et al., 2016). Australian growers specifically cite barriers in the form of added expenses and lack of time, knowledge, and/or markets, to sell value-added products (Duarte Alonso & Northcote, 2013). This research focuses on one strategy presented in Figure 1: re-thinking, re-processing, redesign (using parts, or all, of a discarded product in a new, improved product). A study by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) shows valuable food ingredients and snack products can be produced using vegetables, which are dried and ground to a powder, with minimal loss of nutrients (CSIRO, 2018a). "Extrusion" (i.e. mixing, cooking, shearing, puffing, shaping, and drying) is a process designed to produce a wide variety of foods in sectors such as snacks, ready-to-eat (RTE) cereals, biscuits, confectionery, and extruded crisp breads. Presently, however, the technology is restricted to two types of biomass – whole carrots and broccoli (CSIRO, 2018b). Market reports also highlight the trend towards health and wellness, along with convenience, in the food and beverages industry, with companies using different strategies to address such trends that include more plant-based ingredients in high growth sectors (i.e. beverages, snacks, cereals, and baked goods) and provision of premium priced, value-added food products with significant health claims (CSIRO, 2017; Euromonitor, 2017a, 2017b). Turning fruit and vegetable residues into higher value products allows growers to capture more value in the supply chain. Potential benefits are increased competitiveness by generating additional profits and reducing disposal costs (Lin et al., 2013), better health outcomes, an increase in the overall quantity of vegetables eaten by Australians, pollution prevention, conservation of scarce resources such as energy, water, labour, land, and agrochemicals, (CSIRO, 2017), and patenting and licensing opportunities.

Critics of a circular economy argue the social dimension (inherent in sustainable development thinking) is absent (Murray et al., 2017) and that, furthermore, the role of consumers as enablers of a circular economy is not outlined (Chamberlin & Boks, 2018;

Kirchherr et al., 2017). Chamberlin and Boks (2018) recently addressed this limitation by examining how businesses providing circular products or services use communications to market their offerings and influence consumer behaviour. This article focuses on consumers' role in purchasing "circular products" and moving the horticultural sector towards a circular economy. To understand reasons for buying a value-added product, the norm-activation model (Schwartz & Howard, 1981) is utilised. This model posits that awareness of consequences (AC) is one factor, amongst others, that influences pro-social or environmental behaviour. Specifically, it refers to whether someone is aware of the negative consequences for others, or for other things one values, when not acting pro-socially (Steg & Vlek, 2009). Food waste is regarded as a moral problem given the inequality of access to food across the globe (Aschemann-Witzel, Jensen, Jensen, & Kulikovskaja, 2017; Neff, Spiker, & Truant, 2015) and the rising problem of food security (Foley et al., 2011; Godfray et al., 2010). There is ample evidence that consumers feel guilty, uncomfortable, or bothered, to some extent, if they waste food (Brook Lyndhurst, 2007; Hamilton, Denniss, & Baker, 2005; Parizeau, von Massow, & Martin, 2015; Setti, Falasconi, Segrè, Cusano, & Vittuari, 2016; Stefan, van Herpen, Tudoran, & Lähteenmäki, 2013; Watson & Meah, 2012) and several scholars link food waste avoidance to moral judgements (Bortoleto, Kurisu, & Hanaki, 2012; Gjerris & Gaiani, 2013; Stancu, Haugaard, & Lähteenmäki, 2016). Hence, based on the existing research and conceptual model reviewed, the following hypothesis is proposed:

H1: People who are willing to buy value added foods show more awareness of the food waste problem than those who are not willing to buy value-added foods.

Methods

Research instrument

Data was collected using a questionnaire which contained measures of willingness to buy value-added foods, awareness of the food waste problem, motives for buying value-added foods, as well as demographic information, such as age, education, gender, and income level. The concept of value-added foods was sourced from food scientists after attending workshops on food waste organised by the CSIRO. The CSIRO team aims to create healthy food ingredients and products from edible biomass left in the field, lost biomass after harvest, or from side-streams of food processing (CSIRO, 2018a). This represents a circular economy approach to reduce food waste (i.e. by reprocessing lost biomass to value-added food) and a move away from a linear economy approach of disposing food waste. Three types of value-added food made from fruit and vegetable waste were identified (a vegetable powder made from 100% whole carrot that can be used as a healthy ingredient for smoothies, dips, sauces, etc., an "on-the-go" vegetable snack product made from 20% broccoli, and a fermented product based on vegetables that is rich in nutrients and fibre and can be used in products such as baby food, dips, and smoothies. To understand consumers' willingness to buy value-added food, we asked the question, *Are you willing to buy any one of the following products that can be made from fruit and vegetable waste?* Consumers then indicated their willingness to buy, which was measured for each of the three types of value-added products using a seven point scale, anchored from extremely unwilling (1) to extremely willing (7).

We measured general awareness of the food waste problem using six items taken from a scale developed by Delley and Brunner (2017). Some of these items were previously used by Stefan et al. (2013) and Gjerris and Gaiani (2013). The measure included three components: awareness of the social, environmental, and financial consequences of food waste. Perceived food scarcity and a general awareness of the intrinsic value of food, which is linked to the natural environment, and an item that measured attribution of responsibility for the food waste problem were included. Respondents were asked to rate their level of agreement or disagreement with given statements that also used a seven point scale, anchored from very strongly disagree (1) to very strongly agree (7). The six scale items were: *Food waste is a big environmental issue*; *In my country, households are responsible for a great proportion of the food waste*; *Food waste is an important social issue (e.g. world hunger)*; *Foods are scarce over the world and should be consumed consciously*; *Foods are gifts of nature and have to be treated as such*; and *In my country, the food waste generated by households has great financial consequences*. The six item scale had a Cronbach's alpha of .853 ($M = 5.07$, SD = .88), confirming the reliability of the scale. We also measured perceived consumer effectiveness in curbing food waste with one item *I believe that every little effort by consumers helps to reduce the food waste problem* using a seven point scale (Thφgersen, 1999). Lastly, consumers' motives for buying value-added food were assessed by respondents ranking six factors that would influence their demand for value-added food. The six factors considered consumer demand for health and price, but also effects on humans versus effects on the environment. These items have been used in prior research relating to sustainability, notably clean energy (Poortinga, Pidgeon, & Lorenzoni, 2006).

Sampling and recruitment

Ethics approval was secured from the Human Ethics Committee in the first author's university (H6601). A pre-test of the questionnaire was undertaken with the help of students and three marketing scholars, highly experienced in consumer behaviour, who reviewed the research instrument. The target population were food shoppers who had responsibility for food shopping, cooking, or waste disposal. An online panel provided by Qualtrics Data Service was utilised to recruit respondents given the use of panels is becoming increasingly common in food waste studies (Birau & Faure, 2018; de Hooge et al., 2017; Ilyuk, 2018; Mallinson, Russell, & Barker, 2016; Stancu et al., 2016). We employed a quota sampling method to ensure the distribution of gender and age was aligned with the population of Australian food shoppers. An incentive (the chance to win a $100 voucher) was used to encourage research participation. To reduce social desirability biases (van de Mortel, 2008), an online questionnaire and a guarantee of anonymity were used to counteract inclinations to offer "socially correct" answers. Data was collected from April 2018 to May 2018 and a total of 330 usable questionnaires were obtained.

Findings

Summary statistics

Of the 330 respondents, more women (68.5%) than men participated in the survey. Income levels were diverse, with an estimated 13.9% having a total household income

of less than $20,000 and 15.7% earning between $100,000 and $200,000. Data from the Australian Bureau of Statistics (ABD, 2016a) shows the average annual gross household income was $109,668 in 2015–2016 before tax and Medicare levies. Hence, our sample captured the low and average income earners, but also some of the high-income earners. The sample was well educated, with 21.5% reporting a Bachelor's degree as their highest level of education, in contrast with approximately 17% of Australia's population having a Bachelor degree (ABS, 2016b). The most common (27%) age category was 30–39, a quarter of the sample (25.8%) was in full-time employment, 3 persons was the mean household size and close to half of the sample (43.6%) had young children, aged under 12, in the household (see Table 1).

Willingness to buy value-added foods

Respondents showed moderate willingness to buy three types of value-added food products made from food waste. Most (51.5%) were willing to buy vegetable snack products,

Table 1. Respondents' demographic profile.

	Data values	% of Sample
Age	≤20 years	2.42
	21–29	22.12
	30–39	26.97
	40–49	14.55
	50–59	10
	≥60 over	23.94
Employment status	Full-time	25.76
	Part-time	23.33
	Seeking work	5.45
	Retired	19.09
	Home duties	18.79
	Student	5.45
	Other	2.12
Education	No qualification	2.73
	Year 10 or 12 certificate	33.64
	Trade certificate/vocational	8.48
	Certificate	14.85
	Diploma	11.21
	Bachelor's degree	21.52
	Post-graduate degree	7.58
Household size (# of persons)	1	7.58
	2	13.33
	3	31.82
	4	21.52
	5	7.58
	6	4.24
Children in household	0	56.36
	1	19.7
	2	17.88
	3	3.64
	4	1.82
	≥5	0.6
Household income	≤$19,999	13.94
	$20,000–39,999	18.49
	$40,000–59,999	18.78
	$60,000–79,999	15.46
	$80,000–99,999	16.06
	$100k–$199,999	15.76
	≥$200,000	1.52

46.9% the vegetable powder and 44.2% the fermented product. Over a quarter were "neither willing nor unwilling" to buy the value added food products based on food waste (27–29%) as Table 2 details.

Factors influencing demand for value-added foods

Table 3 presents descriptive statistics for the question, *What factors are most important in influencing your decision to buy a new food product that uses fruit or vegetable waste as a raw material?*

"Helping farmers/growers to prevent food waste" was perceived as more important than all other factors, with 62% ranking this in their top two preferences. "Positive effects on the natural environment" (36%) and "effects on the economy" (34%) were of second-most importance while, "meeting the needs of the price-conscious consumer" received the lowest importance (19%) across the top two preferences. Findings for factors influencing the demand for value-added foods were obtained by comparing those willing and unwilling to buy a value-added snack food product. "Willingness to buy" was recoded into two groups, "willing" (score of 5, 6, or 7) and "unwilling or neutral" (score of 1, 2, 3, or 4). Results appear in Tables 4 and 5.

Comparing the two groups, "helping farmers/growers to prevent food waste" was selected by both as the most important factor influencing demand. Although many consumers knew value-added food is a solution to farmers' food waste issues, they did not necessarily show a willingness to buy value-added food. In contrast to those unwilling to buy value-added food, more in the "willing" group selected "meeting consumer demand for healthy food" and "positive effects on the natural environment."

Cognitive factors in willingness to buy value added foods

T-tests were performed to explore differences between those "willing" (responses >5) and "neutral or unwilling" to buy a value-added snack food product. The "willing" group had higher awareness of food waste consequences, general awareness of the intrinsic value of food as a scarce natural resource, believed households are responsible for food waste and believed preventing food waste depends on individual actions (Table 6).

Discussion & conclusions

Due to the scale of the food waste problem, there is an urgent need to move towards a circular economy. A circular economy model deals mainly with materials and resources. Incorporating the consumer perspective into a circular economy model provides essential knowledge for decision-makers. This article presented findings from a questionnaire undertaken to examine the willingness of Australian consumers to buy food made from underutilised biomass. Results illustrated there are significant differences in attitudes between those who are willing to buy value-added foods and those who are neutral or unwilling. Empathy and care for farmers' welfare was a purchasing criterion. By synthesising examples of "circular" activities, products, and companies in the horticultural sector, potential benefits for regional and rural Australia were outlined. Unlike other studies on the circular economy, which tend to focus on industrial

Table 2. Willingness to buy value-added foods derived from food waste by percentage ($n = 330$).

Item	Sample mean	Standard deviation	Extremely unwilling	Not at all willing	Unwilling	Neither willing nor unwilling	Willing	Very willing	Extremely willing
Vegetable powder	4.22	1.484	7.3 (24)	7.6 (25)	9.1 (30)	29.1 (96)	30.9 (102)	11.2 (37)	4.8 (16)
Vegetable snack	4.37	1.460	6.1 (20)	5.2 (17)	10.6 (35)	26.7 (88)	33.9 (112)	10.3 (34)	7.3 (24)
Fermented product	4.11	1.460	8.5 (28)	6.1 (20)	12.1 (40)	29.1 (96)	30.9 (102)	10 (33)	3.3 (11)

Table 3. Factors influencing demand for value-added foods ($n = 304$).

Ranking factor	1 % (*n*)	2 % (*n*)	3 % (*n*)	4 % (*n*)	5 % (*n*)	6 % (*n*)
Helping farmers/growers prevent food waste	37.9 (125)	24.1 (70)	12 (35)	8.6 (25)	5.5 (16)	6.9 (20)
Effects on economy	10.7 (31)	23.7 (69)	18.2 (53)	21.3 (62)	16.8 (49)	8.9 (26)
Meeting consumer demand for healthy food	11.7 (34)	12 (35)	15.8 (46)	21.3 (62)	23 (67)	16.2 (47)
Positive effects on natural environment	19.6 (57)	16.5 (48)	21.6 (63)	16.2 (47)	15.8 (46)	10.3 (30)
Helping society	7.9 (23)	14.8 (43)	20.3 (59)	19.9 (58)	21.3 (62)	15.8 (46)
Meeting needs of price-conscious consumer	11.7 (34)	7.2 (21)	11.3 (33)	11.3 (33)	17.2 (50)	40.5 (118)

Scale: 1 = first factor to 6 = last factor influencing decision to buy value-added foods

Table 4. Factors influencing those "willing to buy" value-added foods ($n = 212$).

Factor	1 % (*n*)	2 % (*n*)	3 % (*n*)	4 % (*n*)	5 % (*n*)	6 % (*n*)
Helping farmers/growers prevent food waste	41% (87)	26% (56)	12% (26)	10% (21)	6% (12)	5% (10)
Effects on economy	11% (23)	23% (49)	20% (42)	20% (43)	16% (35)	9% (19)
Meeting consumer demand for healthy food	13% (28)	12% (25)	15% (31)	21% (45)	24% (51)	15% (32)
Positive effects on the natural environment	22% (47)	15% (31)	22% (46)	17% (36)	15% (32)	9% (20)
Helping society	7% (16)	16% (35)	20% (42)	20% (43)	19% (40)	17% (36)
Meeting needs of price-conscious consumer	11% (24)	7% (14)	11% (23)	10% (21)	18% (39)	4% (90)

Table 5. Factors influencing those unwilling to buy value-added foods ($n = 79$).

Factor	1 % (*n*)	2 % (*n*)	3 % (*n*)	4 % (*n*)	5 % (*n*)	6 % (*n*)
Helping farmers/growers prevent food waste	48% (38)	18% (14)	11% (9)	5% (4)	5% (4)	13% (10)
Effects on economy	10% (8)	25% (20)	14% (11)	24% (19)	18% (14)	9% (7)
Meeting consumer demand for healthy food	7% (6)	13% (10)	19% (15)	21% (17)	20% (16)	19% (15)
Positive effects on natural environment	13% (10)	21% (17)	21% (17)	14% (11)	18% (14)	13% (10)
Helping society	9% (7)	10% (8)	21% (17)	19% (15)	28% (22)	13% (10)
Meeting needs of price-conscious consumer	13% (10)	9% (7)	13% (10)	15% (12)	14% (11)	35%(28)

Table 6. Group attitudes towards food waste and willingness to buy a value-added snack food.

	Full sample	Group 1 mean willing	Group 2 mean neutral /unwilling	Sig.(*t*-test)
Awareness of the consequences of food waste				
Food waste is a big environmental issue	5.17	5.39	4.94	.000
Food waste is an important social issue (e.g. world hunger).	5.36	5.54	5.18	.006
In my country, the food waste generated by households has great financial consequences	4.72	4.92	4.53	.002
Awareness of food scarcity				
Foods are scarce over the world and should be consumed consciously	5.26	5.42	5.16	.027
Foods are gifts of nature and have to be treated as such	5.21	5.34	5.08	.042
Attribution of responsibility				
In my country, households are responsible for a great proportion of the food waste	4.83	5.09	4.54	.000
Perceived consumer effectiveness				
I believe that every little effort by consumers helps to reduce the food waste problem	5.15	5.28	4.81	.002

processes and activities, such as design for disassembly and recycling, this research focused on the consumer perspective, contributing to the small, but growing, literature advocating a more nuanced perspective on the circular economy (Chamberlin & Boks,

2018). Almost half of the sample who completed the questionnaire were willing to buy novel, value-added snacks, a "circular food product", even though they did not have actual product experience. Our results showed awareness of the consequences of food waste was significant in differentiating between people who are willing to purchase value-added foods and those who are not. Furthermore, consumers selected response options, such as helping farmers and caring for the natural environment, as factors that would motivate their purchase. These findings supports other studies highlighting morality is an influential factor in explaining how people feel about food waste, as well as their intentions to avoid wasting food (Bortoleto et al., 2012; Gjerris & Gaiani, 2013; Parizeau et al., 2015; Setti et al., 2016; Stancu et al., 2016; Stefan et al., 2013; Watson & Meah, 2012).

Some scholars argue that raising customer awareness may lead to more sustainable behaviour (Whitehair, Shanklin, & Brannon, 2013). Hence, the recommendations this research offers marketers is, when designing marketing communications for a circular economy, they should highlight empathy and care for farmers and show the various consequences of food waste for people and the natural environment, as well as educate consumers about their responsibility in curbing food waste. Although this article revealed the market potential for novel, value-added foods, caution is advisable. Academic research on the adoption of innovations has shown that intentions are far from perfect predictors of behaviour (Arts, Frambach, & Bijmolt, 2011). Findings linking willingness to buy value-added food and consumers' awareness of the food waste problem found correlation, yet, future research could be conducted to test if a causal relationship exists by using other methods or statistical tests.

Future research may also wish to qualitatively explore consumer attitudes towards "circular foods" or circular economy principles, how consumers can be involved in closing food waste loops (i.e. by sharing food, composting, accepting seconds, etc.), or whether ethical issues (i.e. supporting farmers) conflict with other considerations (i.e. price, quality perceptions, avoiding packaged products, eating fresh produce). Food choice experiments or taste tests and willingness to purchase offer other alternatives, particularly since consumer taste is the single largest determinant of food choice (Verbeke, 2005). A diversity of factors explain early adoption of new products by consumers and other theories, such as the diffusion of innovation model (Rogers, 2003), or theory of planned behaviour (Ajzen, 1991), may be useful to explain adoption. This article's conceptual model may be used to incorporate other variables that increase, or deter, consumer demand for novel foods (Bredahl, 2001; Lusk et al., 2014), such as environmental concerns, personal values, health concerns, level of involvement with food, personality characteristics, or product-related attributes (i.e. price, taste, branding, eco-certification, natural attributes, etc.). Finally, semi-structured interviews with experts in the horticultural supply chain could be undertaken in relation to how the principles of a circular economy could be enacted, the type of training and knowledge required, and measures of performance or "circularity indicators" (Ellen MacArthur Foundation, 2015).

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