

Final Report

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Collagen Business Case Report

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1 Executive Summary

Collagen is the most abundant source of protein in the human body. It binds cells and tissue together, and maintains the body's integrity, shape and strength. However, collagen levels naturally decline as humans age, which adversely affects humans' general health and wellbeing. There has been growth in interest and demand for collagen-based products that are obtained through various animal sources, including bovine, ovine, porcine, marine and poultry.

This project evaluates the current state of the market for collagen, and forecasted future growth for bovine and ovine collagen producers, together with emerging opportunities for higher value returns from collagen. The global collagen market size has an estimated valuation of \$3.136 billion USD for 2018. The market is expected to experience compounded annual growth (CAGR) of 5.09% from 2017-2025, resulting in an estimated market size of \$4.150 billion USD in 2025 (QY Research 2018).

Consumer interest in collagen-based products is growing in various applications, including food and beverage, nutraceutical supplements, cosmetics and medical products. Consumers are particularly focusing on health and performance nutrition, with the nutraceutical collagen market forecasted to account for 40.06% of collagen product sales in 2025.

Collagen's characteristics as a bioavailable bonding material has resulted in growth in both cosmetic and medical applications. Its most prevalent use among cosmetic consumers is in skincare products, with this popularity due to its 'revitalising' and 'renewing' properties. Advanced medical applications such as tissue regeneration and bone substitutes are beginning to use collagen; a potential lucrative new frontier for medical collagen is artificial organs, with research being undertaken into 3D printable organs using biomaterials like collagen (Breed 2017).

Challenges for Australian companies looking to compete in the red-meat collagen market

Marine Collagen: Why it is a barrier:

- Higher projected compounded annual growth (CAGR) at 6.33% through to 2025 (bovine forecasted at 4.61%)
- Doesn't have same speculation regarding safety of consumption (BSE outbreaks cause uncertainty among many consumers)

How to overcome this barrier:

- Marine collagen extracted at lower yield from raw material collagen extraction (1.2% yield; bovine collagen extracted at 8-20% yield)- less efficient process
- Lower yield = higher price; marine collagen costs \$44539 USD/ metric tonne, whereas bovine costs \$33457/MT. Cost leadership allows bovine collagen to have big cost advantage in lower-value products (e.g. food)
- Australia has BSE-free status; big selling point for bovine collagen-based products

- Focus on medical and nutraceutical applications; BSE-free bovine collagen commonly used due to being more genetically compatible with humans than marine

Ovine Collagen can only be produced by Holista Colltech in Australia and NZ (2018):

Why this is a barrier:

- Holista Colltech has a patent on production process for ovine collagen- they have exclusivity to produce ovine collagen in Australia & New Zealand
- Australian ovine is the only disease and prion-free ovine in the world: Holista basically have a monopoly on the ovine collagen market

How to overcome this barrier:

1. Explore the possibilities of using a different extraction process- can this be used to circumvent the patent?
2. Invest in Holista Colltech- opportunity to form partnerships: there is excess demand for ovine collagen- a partner investment may help raise production to meet demand
3. Focus solely on bovine collagen opportunities- access to lucrative value-adding opportunities for bovine collagen is open; major medical market players using BSE-free bovine collagen

Counter-acting growing vegan population: Other challenges for red meat collagen include a growing vegetarian/vegan population who will not consume animal collagen products; additionally, 3% of the world is allergic to bovine collagen. These problems cannot inherently be solved; however, the negative impact of these consumers on the market can be minimised through sustainable production of bovine/ovine herds and raising public awareness of the benefits of collagen supplements for consumers.

Recommendations for Australian bovine/ovine collagen companies:

There is opportunity for bovine collagen to increase its annual collagen supply by 40,000 tonnes to meet market demand in 2025. Based on a 10% yielding extraction process, this is equal to 400,000 tonnes of raw bovine product. Should Australia take 12% of this (in proportion with 2016 bovine export data), the value for secondary bovine product is forecasted to have nearly doubled by 2025. Below are some points of focus for Australian producers.

1. **Focus on high-value opportunities-** the nutraceutical market segment

Countries such as Brazil and China can undercut Australian collagen producers on price due to factors such as lower cost of labour. Therefore, it is important for Australian companies to service high value applications. The nutraceutical segment will experience the highest growth in demand between 2017 and 2025 and is the second highest value per tonne market segment as well.

2. Marketing of BSE-free status

As discussed, Australia's BSE-free status is a significant competitive advantage and will be a key selling point of bovine collagen in coming years.

3. Growing demand for Halal/Kosher certified products

Consumers of Muslim and Jewish faith are religiously forbidden to eat porcine-based products. Therefore, bovine and ovine collagen have a good opportunity to cater to these consumers by obtaining Halal/Kosher certification. Marine is also able to cater to these consumers, so BSE-free countries (i.e. Australia) will need to take initiative to service the growing demand.

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3 Introduction

3.1 Background

MLA's "High Value Food Frontiers" strategy has an aspiration goal to significantly change the current paradigm of commodity red meat offer with innovative products and services that represent a 3-5 value multiplier in value; and that by 2025, 50% of the value will be derived from these HVFF streams instead of current commodity offers.

Collagen has traditionally been processed in Australia as a commodity product and marketed accordingly. However, some overseas companies are developing food, beauty and sports supplements underpinned by the health benefits of high quality beef derived collagen. These products are being imported and targeting changing consumer lifestyles and behaviours to address high value market needs.

This report analyses the consumer trends affecting the market for high value collagen products and provides recommendations based on these trends and market data. These recommendations provide insight into potential opportunities for Australian companies interested in red-meat value-adding opportunities, as well as challenges that will need to be overcome to become a successful player in the collagen market.

4 Objectives

The objectives of this project involved the following:

- Future scenario business model opportunities for collagen supported by data collection and analysis using excel charts and reports.
- Recommendations on activities that would improve the value of collagen and resultant positive contribution to the Australian red meat industry.
- Final delivery of a sanitised case study report which describes key lessons learnt, framework developed and recommendations for MLA to make available on MLA website.

5 Methodology

5.1 Desktop research

Desktop research was undertaken through Internet searches. Databases such as Mintel Innova Market Insights Database and University sources were used to enforce previous findings with organised information on market trends.

Extracts of a report on the global collagen market authored by QY Research (QY Research 2018) was obtained to validate general findings with consistent data that was obtained through primary research, secondary research and with industry contacts. Figures from these are displayed throughout the report and are listed in the appendices.

5.2 Industry consultation

Industry research was undertaken by communicating with a range of companies who are considered market leaders in various capacities within the collagen market. Communication with industry parties was established through emails and phone call.

In-depth interviews were conducted with two Australian-based companies in particular; Gelita and Holista Colltech. Greenleaf gratefully acknowledges the time and information that they contributed to this project.

Communication also occurred between Greenleaf and Freeze Dry Industries, a company interested in collagen value-adding opportunities and potential commercial applications for their business within the collagen market.

6 Global Collagen Market

6.1 Definition of Collagen

Collagen is the body's primary structural protein that maintains shape, integrity and strength of the body. As humans age, their natural collagen production decreases, which adversely impacts on their wellbeing. As consumers are becoming increasingly focused on health and wellbeing, the market for products that provide boosts in the body's collagen levels has experienced steady growth in recent years, with a focus upon products containing animal-based collagen. The market for value-added collagen products is expected to experience continued growth in the years to come.

In the following sections, reference will be made to different 'types' of collagen. These refer to where the collagen was sourced from the animal. 29 types of collagen have been identified, with over 90% found in Type I and III, and Type II, IV and V, accounting for most of the rest. Types I – V are in the following:

- Type I: 80% of dermis (skin), tendons, organs, bone
- Type II: Cartilage
- Type III: 15% of dermis (skin), reticulate fibres (e.g. bone marrow)
- Type IV: Base for cell membranes
- Type V: Dermal junction, placental tissue

6.2 Global Market Size

Global market for collagen peptides forecasted at \$4.150 billion USD in 2025

According to data from QY Research, the global collagen market size has an estimated valuation of \$3.136 billion USD for 2018. The global collagen market is expected to experience compounded annual growth (CAGR) of 5.09% from 2017-2025, resulting in an estimated market size of \$4.150 billion USD in 2025 (QY Research 2018).

6.3 Applications for Collagen

Table 1 provides an overview of the current annual sales by volume (measured in metric tonnes; values as of 2017) and the projected future sales by volume (for 2025) for collagen peptides. It also shows market share by application and expected compounded annual growth rates for each application (QY Research 2018).

Application	2013 (MT)	2017 (MT)	2025 (MT)	Market Share in 2025	CAGR (%) 2017-2025	Revenue (million USD 2017)	\$/MT 2017
Food	17,614	21,694	32,399	27.23%	5.14%	692.38	31,916
Nutraceuticals	25,989	32,125	47,665	40.06%	5.06%	1,262.13	39,288
Cosmetics	6,605	8,239	12,374	10.40%	5.22%	306.81	37,238
Medical	9,117	11,183	16,812	14.13%	5.23%	447.26	39,995
Other	5,243	6,751	9,733	8.18%	4.68%	241.79	35,815
Total	64,568	79,993	118,983	100%	5.09%	2,950.38	36,883

Table 1: Statistics for Collagen Market by Application

The market for collagen peptides in nutraceuticals is the largest and is expected to remain so over the next eight years, with a forecasted 40.06% market share in 2025. Food applications are the second largest, with a forecasted 27.23% market share. Comparatively, medical and cosmetic applications for collagen are smaller, with forecasted 2025 market shares of 14.13% and 10.40% respectively.

Additionally, the \$/MT is not as variable as may be expected. Food does have a significantly lower \$/MT, due to the competitive pricing of commodity food products. However, the pricing for nutraceuticals, cosmetics and medical collagen peptides are all similar. This implies one of two possibilities:

1. The high-value applications for medical collagen products (worth \$ millions per kg) are a very small proportion of the overall medical collagen market.
2. There is little difference between the grade of raw collagen peptides supplied for each application, and most of the value-adding happens after raw material collagen extraction.

It is more likely that the second of the two possibilities is true, as no medical grade collagen-based products have been found through research that are worth less than \$10,000 USD/kg. Section 8.3 provides examples of medical products and their price/kg.

6.4 Product Trends

The following table (Table 2) provides an overview of consumer trends that are impacting each application, and the product opportunities that are arising as a result of these trends.

Application	Consumer Trends
Food & Beverage	- Millennials & young consumers are becoming more adventurous in consumption of health food & drinks

	<ul style="list-style-type: none"> - 70% of consumers are willing to consume unfamiliar food if it has a health benefit (Mintel 2017) - Consumers are focusing on natural sources of food- functional ingredients popular - 'You are what you eat'- consumers are consuming more vitamins & nutrients to feel and look good (Mintel 2017)
Nutraceutical	<ul style="list-style-type: none"> - Nutraceutical supplements focused on ease of use and functionality - Rising middle class- higher disposable income = 88% of consumers willing to pay more for healthy food (Nielsen 2015) - Food is now a means for managing health & reducing disease - Millennials taking supplements to maintain good health- 20% take probiotics for gut health - 47% of AUS consumers avoid refined sugar - Functionality highest claim surrounding health food - 73% of meal replacement drinks aimed at 'weight & muscle gain' (Nielsen 2015) <p>Biggest focus is on natural, healthy functional foods focusing on either:</p> <ol style="list-style-type: none"> 1. General wellbeing 2. Performance nutrition (e.g. strength)
Cosmetic	<ul style="list-style-type: none"> - Asian consumers indulging in 'luxury' cosmetic goods - A rising ageing population causing more demand for skincare products <p>Survey of ten EU states found following about skincare & cosmetics:</p> <ul style="list-style-type: none"> - 71% of consumers see them as important day to day - 80% identify them as important for self esteem - 82% believe they improve quality of life <p>In China & South Korea:</p> <ul style="list-style-type: none"> - Over 50% of premium buyers have extensive, high end beauty routines - 63% are 'very interested' in high-end luxury products
Medical	<p>Products currently in common usage:</p> <ul style="list-style-type: none"> - Tissue engineering and regeneration now common (Silva, et al. 2014) for variety of applications, like dental, orthopaedic, surgical etc. - Collagen-based fillers for cosmetic surgery are growing in popularity - Bone substitutes/fillers available <p>A potential future medical application for collagen is organ transplants. Development into this field has already started:</p> <ul style="list-style-type: none"> - In 2006, bladders were grown from a collagen-based scaffold and were implanted into patient's bodies. (Jain and Bansal 2015) - Experimentation was undertaken in the same year on rats; their ear cavities were successfully reconstructed using a collagen scaffold. - 2010- approximately 500,000 Americans benefit from a transplant annually - 2010- Approximately 108,000 US citizens waiting for suitable transplants; many will die (U.S. Department of Health & Human Services 2013)

Technology is rapidly advancing in the field of tissue regeneration, with scientists now able to 3D print stem cells from cellulose that multiply into a material very similar to human cartilage tissue (CBS News 2017). They are now looking to compounds more biologically compatible with the human body for:

- Development of 3D-printable tissue and organs that can be safely merged into the body.

This may be an exciting and lucrative new frontier for medical-grade collagen.

Table 2: Consumer Trends for Collagen by Application

The following sections provide examples of value-added collagen products for each applications and the relevant consumer trends that they service.

6.4.1 Food and Beverage Products



Figure 1: Examples of Collagen-Based Food & Beverage Products

Figure 1 illustrates food and beverage products that are advertised as containing collagen. Commonly known examples include collagen jelly and gummy products, as well as sausage and burger casings. However, collagen beverages have begun to become mainstream products, particularly in Asia. As seen in the far-right image, the collagen-based beverages are marketed in a similar fashion to health and cosmetic collagen supplements, with key words including ‘anti-ageing’, ‘radiance’ and ‘vitality’.

6.4.2 Nutraceutical Products



Figure 2: Examples of Collagen-Based Nutraceutical Supplements

The products in Figure 2 have a variety of health purposes and benefits. Some, such as Optimum Nutrition's Creatine powder, support muscular strength and endurance, or use slow and fast release proteins to stimulate muscle growth. They also include multivitamins for diet supplementation.

These products are examples of nutritional supplements that are targeted at providing consumers with healthy nutritional supplements that have a particular purpose and give a specific benefit. Some of these benefits include enhanced muscle growth, improved gut health, natural boosts in energy levels and increased strength.

6.4.3 Cosmetic Products



Figure 3: Examples of Collagen-Based Cosmetic Products

The products in Figure 3 are examples of collagen-based products that are commercially sold for cosmetic use. Skincare products include anti-wrinkle creams, face creams and anti-ageing formulas. Other cosmetic applications include hair and nail health products, marketed as products that ‘revitalise’ and ‘replenish’ your skin, with the focus on natural, youthful radiance.

6.4.4 Medical Products



Figure 4: Examples of Collagen-Based Medical Products

The products in Figure 4 are examples of other collagen-based medical products. Products such as these fulfil a wide array of applications; the above products provide only a snapshot

of the possible medical solutions collagen may be able to service in future. Medical products sourced from collagen function for different purposes. These purposes include the natural regeneration of tissue for both dental and surgical purposes, fillers for cosmetic surgery and bone substitutes for increasing the structural integrity of bones.

Table 3 provides a more detailed overview of medical products/devices that commonly use collagen as an active ingredient.

Medical Devices	
Surgical or Medical Application	Product Types
Aesthetic Surgery	Dermal Fillers
Dental Surgery	Bone substitutes and haemostatic sponges
General Surgery	Haemostatic sponges
Orthopaedic Surgery	Bone substitutes, matrixes for cartilage engineering
Vascular Surgery	Coating solutions for vascular prostheses
Visceral Surgery	Prosthetic coatings and anti-adhesion film
Haemodialysis	Compressive haemostatic sponges
Burns and dermal reconstruction	Bi-layered dermal regeneration matrixes

Table 3: Medical devices that use collagen

Collagen is usually used in these products due to its bio-compatibility with human cells, that enable faster regeneration of tissue and other bio-structures.

6.5 Sources of Collagen

Table 4 provides an overview of the market for each source of collagen. These figures are values for the collagen peptides used in value-added products, not the value-added collagen products themselves (QY Research 2018).

Source	Volume Sales (MT) 2017	Volume Sales (MT) 2025	CAGR 2017-2025	Sales Share 2017	Sales Share 2025	Revenue 2018 (million \$ USD)	Revenue Share 2018
Bovine	34,053	48,819	4.61%	42.57%	41.03%	1,186.91	37.85%
Porcine	17,230	23,951	4.20%	21.54%	20.13%	568.81	18.14%
Marine	24,502	40,038	6.33%	30.63%	33.65%	1,200.24	38.28%
Others	4,208	6,175	4.91%	5.26%	5.19%	179.62	5.73%
Total	79,993	118,983	5.09% (Average)	100%	100%	3,135.58	100%

Table 4: Statistics for Collagen Market by Source

All the collagen sources discussed share the following 2 characteristics:

1. Most abundant types are Type I and Type III collagen
2. They are rich in glycine and proline: Glycine promotes lean muscle building, prevents ulcers & diabetes, and is an anti-inflammatory. Proline stimulates collagen synthesis and prevents cell damage (Patiry, n.d.).

The following section provides the benefits and negatives of each collagen source.

Bovine:

- High processing yields
- Most widely used- plenty of raw materials
- Comparatively inexpensive to marine collagen
- Able to be Halal/Kosher certified
- Negative consumer perception due to BSE (see section 5.2.1 for analysis of Australian status)
- Culturally sensitive to those who identify as Hindu, Sikh or Buddhist (Holista Colltech Limited 2010)
- Nearly 3% of the global population is allergic to the usage of bovine collagen

Bovine is primarily obtained from the skin and bone of the cow. Use of the collagen is also impacted by the cow's development stages; for example, foetal bovine dermis is used for skin and wound healing and tendon reinforcement (QY Research 2018). Depending on the quality of bovine hides, the yield from the processing of the hide is 8% to 20%.

Bovine collagen currently has the largest market share by volume sales with 48,819 MT of sales, which equals a sales share of 42.57%. This is expected to decrease to 41.03% in 2025, due to large sales growth of marine collagen.

Porcine

- Cheapest collagen source
- Doesn't suffer from same speculation regarding safety as bovine
- Culturally sensitive- forbidden for those of Jewish or Islamic faith

Porcine collagen is mostly known for its skin benefits (Further Food, 2018); however, as seen in Figure 9, under section 4.7, it is used in a wide range of applications. Market share (by sales volume) for porcine collagen is expected to decrease from 21.54% to 20.13% between 2017 and 2025, with an anticipated sales volume of 23,951 MT in 2025.

Marine

- Highly bioavailable
- Considered as safe for all applications
- More expensive than other sources of collagen- low processing yields (1.2%- 12g of collagen per 1kg of raw materials processed)
- Non-mammalian- not considered as genetically similar, which may adversely affect usage in medical applications

Marine collagen is expected to experience high growth over the next 7-8 years, with a forecasted CAGR of 6.33%. This will result in the sales share of marine collagen increasing from 30.63% in 2017 to 33.65% in 2025. This is likely attributable to a more favourable consumer perception of the safety of marine collagen over bovine collagen.

Ovine

- Not restricted by disease or cultural sensitivity- can be Halal certified
- Highly bioavailable
- Australia = the only disease/prion-free sheep producer in the world
- Holista Colltech (Australian company) has patented rights for production process- they have the exclusive right to produce ovine collagen in Australia and New Zealand. However, this also presents opportunities for investment and partnerships to take advantage of Australia's status as the world's sole disease-free sheep producer (further developed in section 5.3.3)

The production levels of ovine collagen in volume terms have been very small, with Holista Colltech the only company in the world currently involved in ovine collagen production. However, due to the benefits Australian ovine collagen provides, demand has outsourced Holista's supply. They have rejected orders that they cannot realistically meet and are providing food-grade collagen to China for a purchase price worth nearly 3x what Chinese manufacturers can buy locally.

There is also sufficient opportunity for value-adding raw ovine collagen; when fully refined as medical-grade collagen, 10kg has a retail value of \$5.4 million USD.

Poultry

- Generally regarded as safe
- Variable supply- affects the consistency of production (Holista Colltech Limited 2010)
- Possible transmission of avian influenza- may negatively affect consumer perception

Poultry-sourced collagen likely accounts for a significant part of the 'other' source of collagen. It is chiefly processed from chicken feet. However, variable supply and difficulty in processing/extracting poultry collagen prevents its ability to provide consistent supply to manufacturers and will probably inhibit the growth/scalability of poultry collagen in future. This is reflected in an absence of forecasted growth of market share; other sources of collagen dropped from 5.26% to 5.19% of sales share from 2017 to 2025.

6.6 Australian Industry Players

Current gelatine or collagen production in Australia, from beef or sheep, is undertaken by Gelita (Beaudesert, Qld), Devro (Bathurst, NSW), Sonac (Maryborough, Victoria) and Holista Colltech (Perth, WA), amongst others.

Gelita: a world leader in gelatine and collagen production. At their Queensland facility they process hairy cattle hides to make edible gelatine, with 60% to the confectionary industry and the remainder to jelly crystal and dairy applications. Their production goal for 2019 is to produce 4000 tonnes of gelatin.

Devro: involved in the manufacture, import and sale of collagen, fibrous and other food casings. Their administration is situated in Kelso, NSW. Their products include edible casings and films, which are used in the packaging of processed meats (sausages), and non-edible casings and plastics, which are used as protective packaging for processed meats (IBISWorld 2017)

Holista Colltech: as of 2017, they were the only company in the world producing sheep-based (ovine) collagen. Their patent grants them exclusivity to extract collagen from sheep skin in Australia and New Zealand. Additionally, should companies outside Australia seek to copy their patented process, they would not have the same disease-free and prion-free benefits that Holista have. They produce an estimated 48 tonne/annum of food-grade collagen and 24 tonne/annum of cosmetic-grade collagen, from lamb and sheep hides. They are (as of 2017) the only company in the world producing ovine (sheep collagen) and have patented rights to their collagen extraction process.

Based on communication with major market players, the general belief is that while there is currently enough bovine raw material supply to sustain production as it stands in 2018, significant growth in demand for increased output may result in shortages in the necessary bovine raw material from Australian suppliers.

6.7 Key Global Market Players

The companies listed in Table 5 are global leaders in their relevant collagen applications. Certain Australian market leaders have been excluded from the table, as they are evaluated in section 4.6 (i.e. Gelita). An in-depth overview of these companies and their scope of operations is provided in the Appendices (section 7.1).

Company	Base Country of Operation	Relevant Application	Source of Collagen	
JBS- NovaProm	Brazil	Food & Beverage, Cosmetic, Nutraceuticals, Other	Bovine	Collagen pep health produc
Rousselot B.V.	EU, South & North America, Asia	Food & Beverage, Medical	Bovine, Porcine	Gelatin & Col
PB Leiner/ PB Gelatins	Whole World (Large EU)	Food & Beverage, Nutraceutical	Bovine, Porcine	Collagen pep
Ewald Gelatine GMBH	Germany	Food & Beverage	Bovine	Leaf, powder
Certified Nutraceuticals Inc.	USA	Nutraceutical	Marine	Collagen gen
Vital Proteins LLC	USA	Nutraceutical	Bovine, Marine	Collagen pep shakes

Company	Base Country of Operation	Relevant Application	Source of Collagen	
Nitta Gelatin	Asia, North America	Food & Beverage, Nutraceutical, Health, Other	Bovine, porcine, marine	Gelatin and co
Nippi Inc.	Japan	Nutraceutical, Food, Medical, Cosmetic	Bovine, porcine, marine, poultry	Gelatin, collag PVC foams
ProPlenish	Australia	Cosmetic	Marine	Edible collagen
Gold Collagen	United Kingdom	Cosmetic	Marine	Collagen beau
Collagen Solutions PLC	United Kingdom	Medical	Bovine	Medical collag
Collagen Matrix	USA	Medical	Porcine, Bovine	Collagen medi
Geistlich Pharma	Switzerland/ Australia	Medical	Bovine	Natural bone s
Medtronic PLC	Ireland/USA	Medical	Porcine	Collagen repai
Advanced Biomatrix	USA	Medical	Bovine	Collagen powd

Table 5: Overview of Key Collagen Market Players

7 Results & Discussion

7.1 Size of Opportunity in Collagen Market

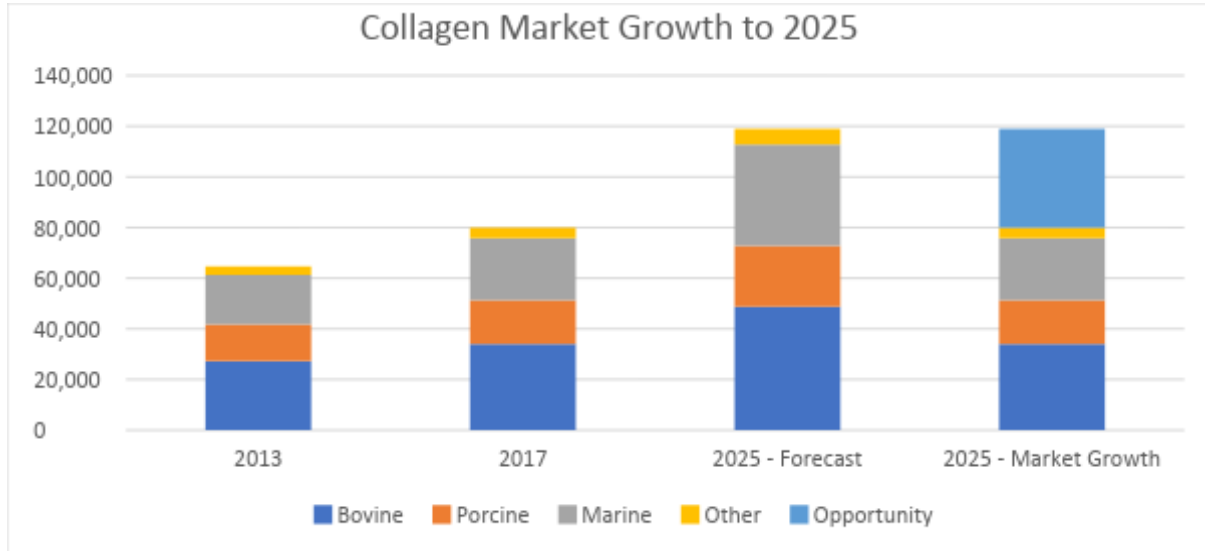


Figure 5: Collagen market growth by volume (MT) to 2025

Figure 5 compares the total volume (MT) of collagen the market needs to meet demand in 2017 and 2025. The light blue section in 2025- Market Growth represents the opportunity for bovine collagen to increase the volume of supply to the collagen market. This represents approximately 40,000 tonnes of collagen. Based on the collagen extraction process for bovine collagen having a yield efficiency of 10%, this means there is opportunity for bovine collagen equal to 400,000 tonnes of raw bovine product (e.g. hides) in 2025.

The value opportunity for Australian bovine collagen to cater to market demand is explained in the analysis of Figure 6.

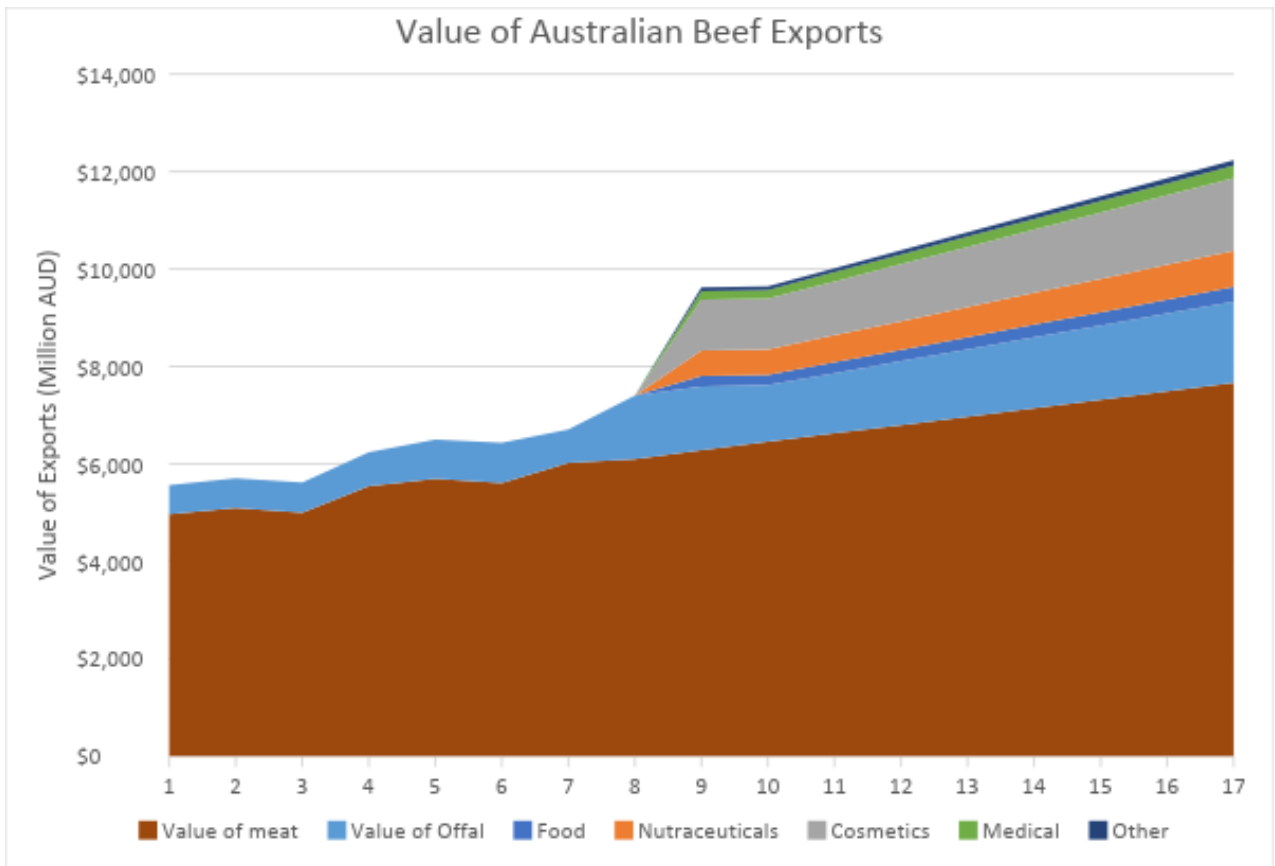


Figure 6: Value Increase for Australian Beef Exports due to bovine collagen production

Figure 6 represents the growth in value Australia will derive from meeting the growing market demand for the relevant collagen products. This is assuming Australia accounts for 12% of bovine collagen products (in proportion with 2016 bovine export figures)- the volume of collagen is distributed evenly across collagen market segments.

Figure 6 shows that the value for secondary products (offal, bones, hides) has nearly doubled between 2017 and 2025. It should also be noted that should Australia leverage the access we have to marketing and technology in a way that emphasises the benefits of using Australian bovine collagen (as discussed in the following sections), the realised value multiplier could be much higher (as Australia will account for a higher proportion of collagen supply than 12%).

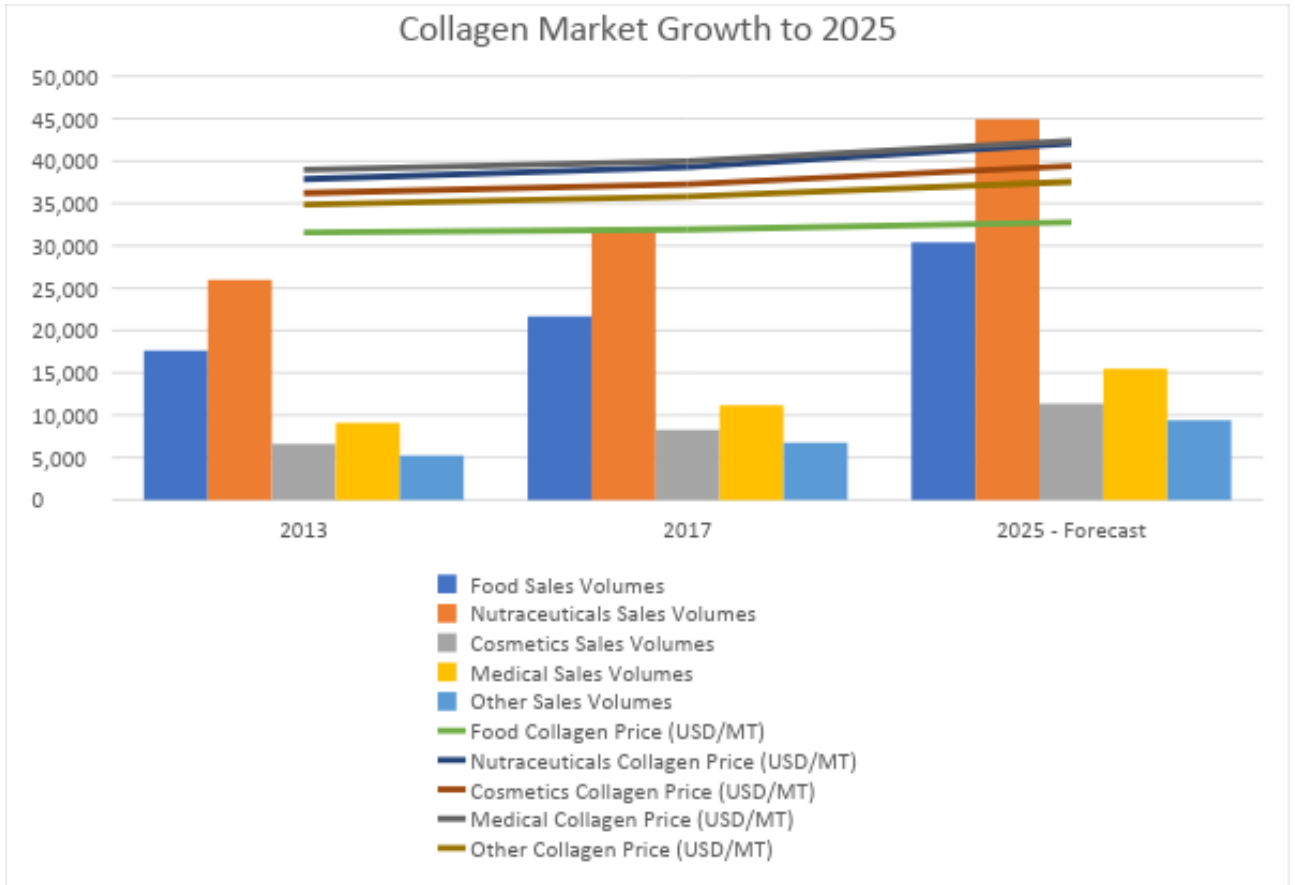


Figure 7: Collagen market segment growth by volume (MT) and value (USD/MT) to 2025

The trend lines in Figure 7 represent the value (USD) per tonne for collagen by segment. Value increase for collagen to 2025 is minimal. The primary increase in market value for collagen is the increase in volume. This increase is largely due to an increase in demand for food and nutraceutical collagen sales. Nutraceutical collagen yields a substantially higher sale price per tonne than food collagen; as the market segment with the highest demand and the second highest \$/MT, this should be an area of focus for collagen producers.

7.2 Competitive Advantage for Australian red-meat collagen value-adding

7.2.1 BSE free status- bovine

The recent outbreak of BSE cases among cattle has resulted in consumer uncertainty regarding the safety of consuming bovine-sourced collagen. This has led to a decrease in its usage in various collagen applications, substituted chiefly by marine collagen. Therefore, it is logical to assume that this provides BSE-free countries (such as Australia) with a competitive advantage for supplying bovine collagen, as their no-risk-of-BSE classification enables them to assure consumers that their products are 100% disease free.

However, while advertising products as BSE-free may be somewhat useful as a marketing tool to influence consumers, it does not actually have any tangible advantage. The OIE Terrestrial Animal Health Code (which is the global standard for animal health and product trading) states that there is no need for veterinary authorities to utilise any BSE related conditions for 'gelatine and collagen prepared exclusively from hides and skins'. This is because there is a negligible risk of disease transmission through products sourced from hides or skins. As hides and skin are classified as Type I and III collagen, the most abundant collagen sources used, the BSE-status of countries manufacturing most bovine collagen products is actually of little relevance.

Despite this, companies involved heavily in production of collagen sourced from bovines believed that BSE-free was a big selling point, particularly to Asian countries. This was due to consumers finding greater security in their knowledge that the collagen contained in their product was sourced from a disease-free country. **Thus, Australian- based companies should seek to market their BSE-free status when selling bovine collagen or BSE-free collagen products.**

7.2.2 Growing demand for Halal/Kosher products- bovine & ovine

Porcine products are forbidden for consumption by people of Islamic and Jewish religion. As a result, demand is expected to rise heavily for bovine/ovine products that are kosher and halal-certified.

Marine collagen will also threaten to steal this growth- however, bovine and ovine producers can use to their advantage the more cost-effective and higher yielding extraction processes they have access to. This will enable them to compete effectively in the halal/kosher market through cost leadership.

7.2.3 Cost Leadership over marine collagen- bovine

Table 6 in section 8.2 shows the \$/MT based on the collagen source. The 2018 \$/MT for bovine collagen is \$33,457 USD, whereas marine is \$45,539 USD. This is likely due to bovine collagen having a higher-yielding extraction process than marine (8-20% compared to 1.2%); greater efficiency allows bovine collagen processors to charge a more competitive price. While this is not likely to be an influencing factor for high-value multiplier products in medical applications, for low-value commodity products in food applications this is a serious competitive advantage for bovine collagen producers.

7.3 Challenges for Australian red-meat collagen growth

7.3.1 Importance of accessing high-value opportunities

For commodity items such as gelatin, there is heavy competition from countries such as China and South American countries such as Brazil, who can undercut Australia on price. This is due to factors such as lower costs in labour and raw materials. **Therefore, it is critical for Australian companies to look beyond low-value commodity goods and to higher-value opportunities that are emerging within the global collagen market.**

7.3.2 Growing demand for marine collagen products

Market statistics for marine collagen are provided in Figure 7. It can be seen that marine collagen has the highest expected CAGR to 2025, at 6.33%. This will provide the marine collagen market with an approximate 3% gain in volume sales share at the expense of bovine and porcine collagen. Additionally, as it is more expensive than bovine collagen, it will have a higher share of revenue, obtaining 38.28% of revenue share in 2018 compared to 37.85% for bovine collagen.

Thus, marine collagen is a serious competitor for bovine collagen, largely due to its higher bioavailability and perceived higher sustainability. It also does not have the same consumer misgivings regarding its safety for human consumption and is thus considered a safer collagen source than bovine collagen.

As mentioned in section 5.2.3, one of the key points of difference for bovine collagen is the cheaper price per metric tonne, and the more effective extraction processes. Additionally, for medical purposes, key market players such as Collagen Solutions PLC and Advanced Biomatrix use BSE-free collagen. This is likely due to bovine collagen having closer genetic similarity to humans than marine collagen.

7.3.3 Vegan/Vegetarian population growing

Another industry growth inhibitor is the increasingly popular vegetarian/vegan trend. As collagen can be naturally produced, consuming collagen growth stimulants such as silica, vitamins and soy are collagen alternatives that vegetarians and vegans may take so they don't have to consume bovine collagen sources (Lam-Feist 2017).

The negative impact of these consumers on the red-meat collagen market can be minimised through sustainable production of bovine/ovine herds and raising public awareness of the benefits of collagen supplements for consumers.

7.3.4 Ovine collagen production restricted

As mentioned previously, Holista Colltech has a patent on the production process for ovine collagen, that grants them exclusivity to produce this in Australia and New Zealand. Additionally, countries that wish to produce ovine collagen outside Australia/New Zealand

will not have access to the same disease-free and prion-free benefits that Holista do. With these factors in play, three viable options with regards to ovine collagen are:

1. Focus solely on bovine collagen opportunities

The market for bovine collagen is large and developed, with bovine collagen being widely used across most applications for collagen. Access to lucrative value-adding opportunities for bovine collagen is open, with much of the medical segment opting to use BSE-free bovine collagen over other sources (see Table 5 for examples of major market players who are using bovine collagen). As Australian bovine has BSE-free status, it presents a competitive advantage over countries that do not have this status (as discussed in section 5.2.1). Therefore, Australian bovine collagen is likely to continue as a competitive collagen source in coming years.

2. Explore the possibilities of using a different extraction process

There is some ambiguity regarding Holista Colltech's patent (based on Greenleaf's research). In contact with Holista Colltech, their patent was described as providing them with a process that was not allowed to be copied. It may be possible that if a process sufficiently different to theirs is developed, ovine collagen can be extracted from Australian sheep by other companies. Should this option be of interest, further research into the coverage of the patent and other methods of extraction would be necessary.

3. Invest in Holista Colltech- opportunities to form partnerships

Holista Colltech currently uses a mid-scale production plant to cater for orders from collagen value-adding companies. They are not currently producing at their 72 tonne/annum production target. There is much higher demand than they are able to cater for- an order of 280 tonnes per annum (from China) was rejected due to their factory not being able to meet this level of production sustainably (Williamson 2017).

Holista have registered interest in investment and partnership opportunities. As there is unmet demand for ovine collagen, and Australian ovine collagen has exclusive disease-free benefits, this may be a valuable opportunity for companies looking to value-add collagen to source or create high-value ovine collagen-based products.

7.4 Other Relevant Considerations for red-meat value-adding parties

7.4.1 Other uses of bovine/ovine hides

Most of the bovine/ovine collagen used in value-added products is obtained from the hide of the animals. Therefore, for collagen extraction to be worthwhile for red meat processors, the price obtained for the hide must exceed the value they can obtain from using them for alternative applications such as leather.

7.4.2 De-valuation of Australian red meat skins

Recent de-valuation in the price paid for bovine/ovine skins means that value-adding processes like collagen extraction are becoming more important for the consideration of red meat processors. If greater value can be obtained from skins through collagen extraction than through selling the hides, then red meat processors should explore the equipment they need to facilitate the extraction process and determine how worthwhile/profitable an investment this would be. When extracting collagen, raw materials (hides) account for approximately 82.26% of the cost of extraction (QY Research 2018), as seen in Figure 8.

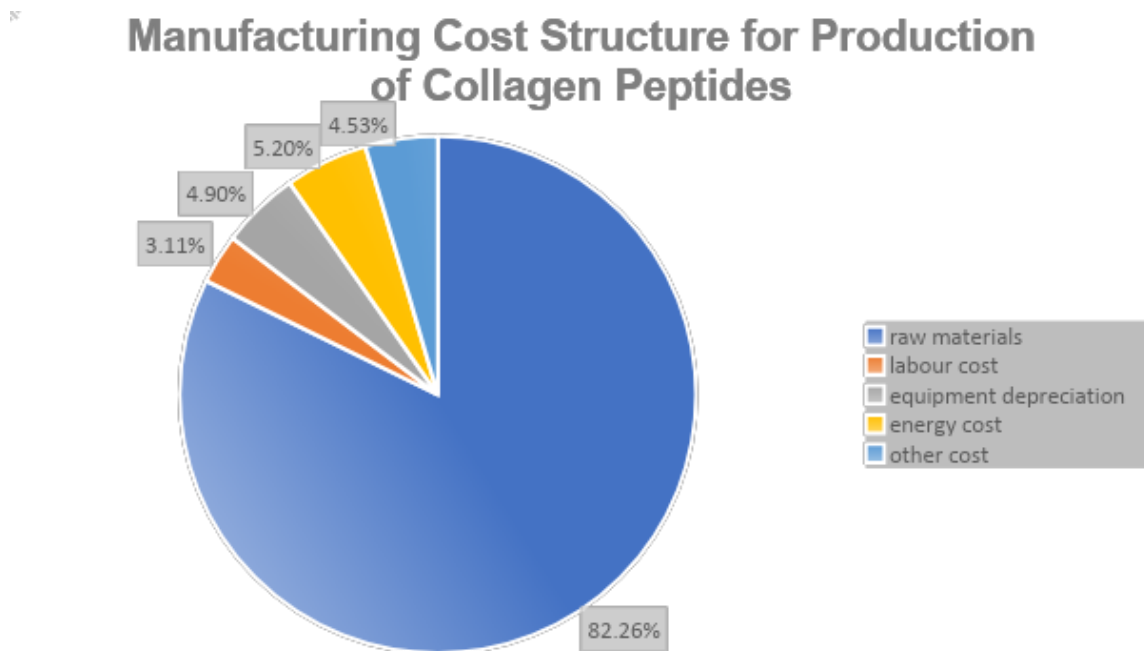


Figure 8: Cost of Manufacture for Collagen Peptides

8 Summary of Findings

For Australian companies, it is important to use the BSE-free status of Australian bovine as a selling point for bovine collagen and value added bovine collagen products. This status will be particularly useful in the medical space and will provide a competitive advantage across all applications. Additionally, Halal/Kosher certification will be of benefit for bovine collagen producers and value-added products, as this will allow them to cater to the growing demand for such products from Muslim and Jewish consumers.

The growth in popularity of marine collagen is a source of competition for bovine collagen, particularly in nutraceutical and cosmetic applications. However, BSE-free bovine collagen will find competitive advantage in its more efficient, higher-yielding extraction processes, which enable it to be sold at a cheaper price per tonne than marine collagen. Countries like Brazil have lower costs than Australia, so Australian producers should be aware that cost leadership may not be a particularly sustainable strategy and should rather focus on high quality BSE-free collagen opportunities in high value applications (i.e. nutraceutical, medical). As nutraceutical collagen also has both the highest market demand and forecasted growth to 2025, it is recommended that Australian collagen producers focus on the nutraceutical collagen segment in the coming years.

Opportunities for ovine collagen production and value-added opportunities is limited by Holista Colltech's patent, which is currently preventing supply from meeting demand. However, this presents a business proposition for interested companies to seek partnerships and investment opportunities with Holista to scale up production and access new high value opportunities for Australian ovine collagen.

Overall, there are a range of value-adding opportunities for red meat collagen producers that will multiply the value obtained from the raw material sources of collagen. It is recommended that companies involved in the Australian red meat industry explore ways to seize the opportunities discussed in this report, through involvement in the value-adding of collagen to service current and future demand for collagen-based products.

9 Bibliography

- Advanced BioMatrix. n.d. <https://www.advancedbiomatrix.com/collagen-type-i/purecol-type-i-bovine-collagen-lyophilized-15mg/> (accessed May 28, 2018).
- Bloomberg L.P. *Company Overview of Nippi, Incorporated*. 2018. <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=881153> (accessed May 23, 2018).
- CBS News. *Scientists hit milestone in 3D printing of cartilage*. 5 May 2017. <https://www.cbsnews.com/news/scientists-hit-milestone-in-successful-3d-printing-of-cartilage/> (accessed June 12, 2018).
- Certified Nutraceuticals. *Healthy Living through Innovative Technology*. 2018. <http://certifiednutra.com/products-telos95.php> (accessed May 28, 2018).
- Covidien. *Covidien Collagen Repair Patch*. 2009. <http://www.medtronic.com/content/dam/covidien/library/us/en/product/sports-surgery/collagen-repair-patch-faqs.pdf> (accessed May 31, 2018).
- delicious. *Why vegan is the fastest growing food movement in the world*. 28 May 2017. <https://www.delicious.com.au/food-files/article/why-vegan-fastest-growing-food-movement-world/pGyK8ZIL> (accessed June 21, 2018).
- Ewald Gelatine. *Quality, Safety and Innovation*. 2018. <https://www.ewaldgelatine.de/english/> (accessed May 29, 2018).
- Further Food. *What are the types of collagen?* 2018. <https://www.furtherfood.com/what-are-the-types-of-collagen/> (accessed June 6, 2018).
- Gold Collagen. *Products*. 2018. <http://www.gold-collagen.com/uk/products> (accessed June 3, 2018).
- Hardman & Co. *Collagen Solutions plc (COS.L) Initiation*. 2014. http://ir.collagensolutions.com/pdf/research/Hardman_Research_24Sept2014.pdf (accessed May 23, 2018).
- Holista Colltech. *Different Sources of Collagen*. 4 June 2018. http://www.holistaco.com/index.php?option=com_content&view=article&id=392 (accessed June 11, 2018).
- Holista Colltech Limited. *OviColl*. 2010. <http://ovicoll.com/about.php> (accessed June 7, 2018).
- IBISWorld. *Devro Pty Limited- Profile Company Report Australia*. 31 December 2017. <https://www.ibisworld.com.au/australian-company-research-reports/manufacturing/devro-pty-limited-company.html> (accessed June 20, 2018).

- iHerb. *Neocell, Super Collagen, Type 1 & 3, 7 oz (198 g)*. 2018. <https://au.iherb.com/pr/Neocell-Super-Collagen-Type-1-3-7-oz-198-g/6074> (accessed June 20, 2018).
- Jain, Aditya, and Ramta Bansal. *Applications of regenerative medicine in organ transplantation*. September 2015. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4517320/> (accessed June 11, 2018).
- Lam-Feist, Monica. "A Vegetarian's Guide to COllagen and Healthy Bones." *AlgaeCal*. 20 July 2017. <https://www.algaecal.com/expert-insights/vegetarians-guide-protein-collagen-healthy-bones/> (accessed May 25, 2018).
- MarketsandMarkets Research Private Ltd. *Collagen & Gelatin Market for Regenerative Medicine (by Source (Bovine, Porcine, Marine), Application (Wound Care, Orthopedic, Cardiovascular)), Value and Volume Analysis - Global Forecast to 2022*. 2017. https://www.marketsandmarkets.com/Market-Reports/collagen-gelatin-regenerative-medicine-market-95663122.html?gclid=Cj0KCQjwuMrXBRC_ARIsALWZrIhlwIML9lr4RifcXMyBqm_3M1G895wB8YDirTW-m2OiHh6xVb-pw9MaAhOXEALw_wcB (accessed May 10, 2018).
- Mintel. *Collagen finds mainstream appeal in smoothie offerings*. 21 August 2017. <http://reports.mintel.com/display/850695/?highlight> (accessed June 6, 2018).
- Nielsen. "We are What we Eat." *Nielsen Global Health and Wellness Survey*. January 2015. <https://www.nielsen.com/content/dam/niensenglobal/eu/nielseninsights/pdfs/Nielsen%20Global%20Health%20and%20Wellness%20Report%20-%20January%202015.pdf> (accessed May 28, 2018).
- Nitta Gelatin. *Unlocking the Potential of Gelatin & Collagen for Over a Century*. 9 March 2018. <http://nitta-gelatin.com/> (accessed May 25, 2018).
- NovaProm. *Collagen & Food Ingredients*. 2018. <http://www.novaprom.com.br/en/> (accessed May 25, 2018).
- Patiry, Megan. *Bovine Collagen VS Marine Collagen*. n.d. <https://blog.paleohacks.com/bovine-collagen-vs-marine-collagen/#> (accessed June 6, 2018).
- ProPlenish. *ProPlenish Shop*. 2018. <https://www.proplenish.com.au/product/anti-ageing-facemask/> (accessed May 31, 2018).
- QY Research. *Global Collagen Peptide Market Research Report*. Commercial , QY Research, 2018.
- Rousselot. *Reaching Further Together*. 2018. <https://www.rousselot.com/> (accessed May 28, 2018).

Roy Morgan. *The slow but steady rise of vegetarianism in Australia*. 15 August 2016. <http://www.roymorgan.com/findings/vegetarianisms-slow-but-steady-rise-in-australia-201608151105> (accessed June 21, 2018).

Silva, Tiago, Joana Moreira-Silva, Ana Marques, Alberta Domingues, Yves Bayon, and Rui Reis. *Marine Origin Collagens and Its Potential Applications*. 5 December 2014. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4278207/> (accessed May 11, 2018).

Tessengerlo Group. *Solugel*. 2017. <http://www.gelatin.com/en/Pages/SOLUGEL.aspx> (accessed June 21, 2018).

U.S. Department of Health & Human Services. *Regenerative Medicine*. 29 March 2013. <https://report.nih.gov/nihfactsheets/ViewFactSheet.aspx?csid=62> (accessed May 15, 2018).

Vital Proteins. *Our Story*. 2018. <https://www.vitalproteins.com/pages/our-story> (accessed June 21, 2018).

Williamson, Rachel. "An ASX-listed company wants to do what with my collagen?" *Stockhead*. 21 August 2017. <https://stockhead.com.au/health/an-asx-listed-company-wants-to-do-what-with-my-collagen/> (accessed May 25, 2018).

10 Appendices

10.1 In-depth overview of global market players

10.1.1 Food & beverage market players

Company: JBS NovaProm

Primary Country: Brazil

Key Applications: Food & Beverage, Cosmetic, Medical, Other

Source: Bovine

Description: NovaProm is a business division of the JBS Group

Company: Rousselot B.V.

Primary Country: EU, South & North America, Asia

Key Applications: Food & Beverage, Medical

Source: Bovine, Porcine

Description: They are a leading producer of gelatin and collagen peptides. (Rousselot 2018).

Company: PB Leiner/PB Gelatins

Primary Country: Whole World (Large EU)

Key Applications: Food & Beverage, Nutraceutical

Source: Bovine, Porcine

Description: They provide easily digestible, quick absorption collagen peptides. (Tessengerlo Group 2017).

Company: Ewald Gelatine GMBH

Primary Country: Germany

Key Applications: Food & Beverage

Source: Bovine

Description: They provide a range of qualities of leaf gelatine, powder gelatine, Halal gelatine and organic gelatine. Users of their products include hotels, restaurants, patisseries, bakeries and households (Ewald Gelatine 2018).

10.1.2 Nutraceutical market players

Company: Certified Nutraceuticals Inc.

Primary Country: USA

Key Applications: Nutraceutical

Source: Marine

Description: They specialise in quality collagen nutritional ingredients for cardiovascular, joint, skin, eye health and anti-aging support (Certified Nutraceuticals 2018).

Company: Vital Proteins LLC

Primary Country: USA

Key Applications: Nutraceutical

Source: Bovine (Australia, New Zealand), Marine (Hawaii)

Description: They promote health, fitness and natural beauty through sustainably-sourced nutrition products. They sell collagen peptide dietary supplements, beauty shakes and protein powders (Vital Proteins 2018).

Company: Nitta Gelatin

Primary Country: Asia, North America

Key Applications: Nutraceutical, Food and Beverage, Health, Other

Source: Bovine, Porcine, Marine

Description: Nitta Gelatin supply high quality gelatin and collagen peptides. (Nitta Gelatin 2018).

Company: Nippi Inc.

Primary Country: Japan

Key Applications: Nutraceutical, Food, Medical, Cosmetic

Source: Bovine, Porcine, Marine, Poultry

Description: They manufacture gelatin, collagen peptides, casings, cosmetics and PVC foams. (Bloomberg L.P. 2018).

10.1.3 Cosmetic market players

Company: Gold Collagen

Primary Country: United Kingdom

Key Applications: Cosmetic

Source: Marine

Description: Gold Collagen provide clinically tested beauty supplements, mainly for skincare purposes, as well as the promotion of healthy hair and nails (Gold Collagen 2018).

Company: ProPlenish

Primary Country: Australia

Key Applications: Cosmetic

Source: Marine

Description: ProPlenish is an Australian brand that was the first to provide edible marine collagen products to the Australian market. Many of their products are provided in a powder form that are dissolvable, and are marketed as 'reinvigorating your skin, hair and nails'. They also provide other cosmetic products like anti-ageing facemasks, which are to be used in conjunction with their collagen oral supplements. (ProPlenish, 2018)

10.1.4 Medical market players

Company: Collagen Solutions PLC

Primary Country: United Kingdom

Key Applications: Medical

Source: Bovine (Australia, New Zealand)

Description: Collagen Solutions create biodegradable/bio resorbable devices, and supply medical collagen biomaterials for research purposes, medical devices and regenerative medicine. Their goal (as of 2014) was to move from acting a supplier of purified, functional collagen that was valued at \$500-\$1,000 per gram to developing and supplying medical devices that contained the same collagen, but were valued at prices upwards of \$1,000 per gram (Hardman & Co, 2014).

Company: Collagen Matrix

Primary Country: USA

Key Applications: Medical

Source: Porcine, Bovine

Description: Collagen Matrix offers collagen and mineral based medical devices that support the body's natural regenerative ability. They provide clinical application solutions for dental, spinal, orthopaedic, dural repair and nerve repair.

Company: Geistlich Pharma

Primary Country: Switzerland/Australia

Key Applications: Medical

Source: Bovine

Description: Geistlich are market leaders in natural bone substitutes for regenerative dentistry. Some of the products they sell include Bone Substitutes, Membranes for tissue regeneration and matrices for soft-tissue regeneration and tissue grafts.

Company: Medtronic PLC

Primary Country: Ireland/USA

Key Applications: Medical

Source: Porcine

Description: Their collagen repair patch is a trusted, reliable soft tissue reinforcement material. Over 250,000 of these patches have been implanted in medical procedures since

1998. It is derived from pig dermis and is used for tissue repair across many surgical disciplines (Covidien, 2009).

Company: Advanced Biomatrix

Primary Country: USA

Key Applications: Medical

Source: Bovine

Description: Advanced Biomatrix is an industry leader in 3D applications for tissue culture, cell assay, and cell proliferation. They sell a wide range of medical solutions and powders (not all collagen-based). They are an industry leader in the science of 3D applications for tissue culture and cell proliferation.

10.2 Figures from QY Research

Source	2013	2014	2015	2016	2017	2018 (E)
Bovine	32,502	32,617	32,636	33,107	33,365	33,457
Porcine	30,215	30,613	30,243	30,910	31,252	31,564
Marine	44,265	44,531	44,081	44,918	45,261	45,539
Others	38,695	38,909	38,672	39,349	39,625	39,796
Average	35,883	36,224	35,906	36,572	36,883	37,166

Table 6: Global Collagen Peptide Price (USD/MT) by source

Application	2013	2014	2015	2016	2017	2018 (E)
Food	17,614	18,615	19,251	20,604	21,694	23,049
Nutraceuticals	25,989	27,792	29,213	30,925	32,125	34,034
Cosmetics	6,605	7,118	7,502	7,967	8,239	8,563
Medical	9,117	9,645	10,360	10,766	11,183	11,811
Others	5,243	5,673	6,019	6,418	6,751	6,910
Total	64,568	68,842	72,345	76,681	79,993	84,367

Table 7: Global Collagen Peptide Sales (MT) by Application (2013-18)

Revenue	2013	2014	2015	2016	2017	2018 (E)
Bovine	890.88	951.46	974.58	1077.66	1136.19	1186.91
Porcine	434.51	470.81	483.09	513.86	538.49	568.81
Marine	864.58	933.78	995.30	1052.94	1108.98	1200.24
Others	126.92	137.68	144.64	159.92	166.73	179.62
Total	2316.89	2493.73	2597.62	2804.38	2950.38	3135.58

Table 8: Global Collagen Peptide Revenue (million USD) by Source

10.3 Examples of collagen products by application and their price/kg (Figure 9)

Company	Product	Application	Collagen-related ingredients	How it is obtained
Advanced Biomatrix	PureCol Lyophilized	Medical- prepares thin layers for culturing cells	Bovine collagen (Type I)	Isolated from hide- >99.9%
	PureCol EZ Gel (5mg/mL = 0.5%)	Medical- Improve gel consistency for cell cultures	Bovine Collagen	
	Bovine Collagen Solution	Medical- provides structure for connective tissue	Bovine Collagen (Type V)	Isolated from placenta- firm of >95%
	Bovine Collagen Lyophilized Fibrous Powder	Medical- prepared into tissue scaffolds, foams, putties etc.	Bovine Collagen (Type I)	Extracted from bovine flexor tendon- >96%
Beauty & Go	Skin Detox Bioactive Beauty Drink	Beverage/Health- Skin purifying drink with antioxidants	Collagen Peptides	
	Bioactive Collagen Shot	Beverage/Cosmetic- Firms skin and smooths wrinkles	Collagen	
Ewald Gelatine	Gelatine Powder	Food- prepared into jellies and mousse	Porcine Collagen	Extracted from hide
	Leaf Gelatine Sheets	Food- prepared into jellies and soups	Porcine Collagen	Extracted from hide
Gelatin Health	Joint Care	Health- Joint Mobility & Cartilage Formation	Bovine Collagen	
	Soft Skin	Cosmetic- Wrinkle reduction & smoother skin	Bovine Collagen	
	Pet Care Collagen	Health- General mobility and wellbeing	Collagen peptides	
Gold Collagen	Gold Collagen Hairlift	Cosmetic- Healthy hair growth	Marine Collagen	
	Pure Gold Collagen	Cosmetic- Hair, skin & nail health	Marine Collagen	
Nature's Way	Beauty Collagen Powder	Cosmetic- Healthy, smooth skin	Collagen (Type I & III)	
	Collagen Bone Broth	Health- Joint & Gut Health	Bone Broth & Hydrolysed Collagen	
The Beauty Chef	Collagen Inner Beauty Boost	Health- Probiotic Elixir (VEGAN Alternative)	Does not actually contain collagen	