



Hide Collagen Feasibility FINAL REPORT

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TABLE OF CONTENTS

TABLE OF CONTENTS.....	2
1.0 EXECUTIVE SUMMARY	3
2.0 INTRODUCTION	4
3.0 PROJECT OBJECTIVES	4
4.0 METHODOLOGY	4
6.0 RESULTS AND DISCUSSION.....	5
Global collagen market overview	5
Market trends & opportunities by category	8
Collagen market players.....	17
Collagen manufacturing and value	19
7.0 CONCLUSIONS/RECOMMENDATIONS	27
8.0 BIBLIOGRAPHY	29

1.0 EXECUTIVE SUMMARY

Australian Country Choice (ACC) have set their sights on investment in their 5th quarter strategy and commissioned a project to explore the preliminary feasibility of hide collagen as a value adding opportunity. Bovine hides have experienced a progressive decline in value over several decades with synthetic alternatives finding favour in textile customers and manufactures alike. Some beef processors are even paying for the removal of this byproduct and hence the interest by industry to investigate the potential to value add this product.

As with Australian red meat, Australian bovine collagen products come with a 'clean and green' image with our disease-free status accompanied by world leading quality assurance standards. Research has found two value streams in the bovine collagen market: medical collagen and nutraceutical collagen. Understandably medical collagen requires strict quality assurance protocols. It was identified that there is one known major medical collagen manufacturer of whom could be a potential strategic partner for ACC and the broader Australian red meat industry. Likewise, Gelita is another hide processor and is conveniently located a short distance from ACC in Beaudesert QLD. Gelita have extensive hide processing capabilities and an established international and domestic market. Whilst nutraceuticals attract a smaller margin than medical, it is a more flexible process enabling quick movement into other categories. There is also a burgeoning market for nutraceuticals as consumers around the world become more health conscious and choose to spend more of their disposable income on functional foods.

Research has indicated that it is feasible to process collagen from bovine hides and it is recommended that ACC proceed with further investigation including developing a strategic plan and making contact enquiries with key domestic collagen processors.

2.0 INTRODUCTION

Australian Country Choice (ACC) and Australian Meat Processor Corporation (AMPC) have embarked on this project to scope and determine the preliminary feasibility of hide collagen as an alternative market for Australian beef hides. There are limited markets for hides as current and in some cases processors are unable to sell hides and subsequently hides are treated as a waste product, being rendered down or worse being disposed of in landfill. With the cost of cattle, eroding processing margins and increased pressures on the sustainability of the beef industry, it is imperative that new options are found for hides. This project investigates the market potential for collagen production for hides in an effort to determine if this could be a valuable opportunity that warrants further value mapping by industry.

3.0 PROJECT OBJECTIVES

- To allow Australian Country Choice the option to further process or retain selling their hides to the textile industry
- To increase the value of a byproduct that is currently costing some processors to be removed ie. Land fill or rendering
- To generate a by-product which has a market that is growing on an annual basis
- Indicate feasibility
- Market insights
- Trends
- For other industry players to have an option for their hides, as current practice is landfill costing some abattoirs large sums
- The option of having a collagen processor in the heart of Australian beef country Queensland with benefit the industry and prevent dumping

4.0 METHODOLOGY

The consultant conducted systematic research to evaluate the market potential and areas of opportunities in the beef hide collagen market. This included the purchase of a market research report with findings from this correlated against learnings from previous research in collagen products by the consultant.

Value chain mapping was completed through knowledge gained through industry experience and desktop research by the consultant. As this was a preliminary feasibility study this is sufficient however next phases of this initiative would require detailed costing through discussion with the different players in the hide collagen value chain.

6.0 RESULTS AND DISCUSSION

Global collagen market overview

Gelatin is the largest collagen product with 72% of all collagen product being gelatin. In 2019 the gelatin market was worth USD\$2,710 million and is expected to experience a CAGR of 7.0% to reach a value of USD\$4,063.8 million by 2025 (Meticuous Research Analysis, 2020). Collagen peptide is the other product category produced and estimated to be worth USD\$1,057.8 million in 2019 and projected to be worth USD\$1,533.7 million by 2025 with a 6.4% CAGR (Meticuous Research Analysis, 2020).

Bovine is the second largest source of collagen globally with approximately 20.1% of all collagen products derived from bovine (see Figure 1) (Meticuous Research Analysis, 2020). The largest source is porcine, holding 55.4% of the market (Meticuous Research Analysis, 2020). Other sources include; fish (11.2%), chicken (5.0%), sheep (3.7%) and other (4.5%) (Meticuous Research Analysis, 2020). It is speculated that porcine is the most common source due to a combination of plentiful supply, low raw product price and lower costs of extraction from the raw source (Meticuous Research Analysis, 2020). This is in line with research indicating that the global collagen market is highly dependent on the price and margin potential of raw materials.

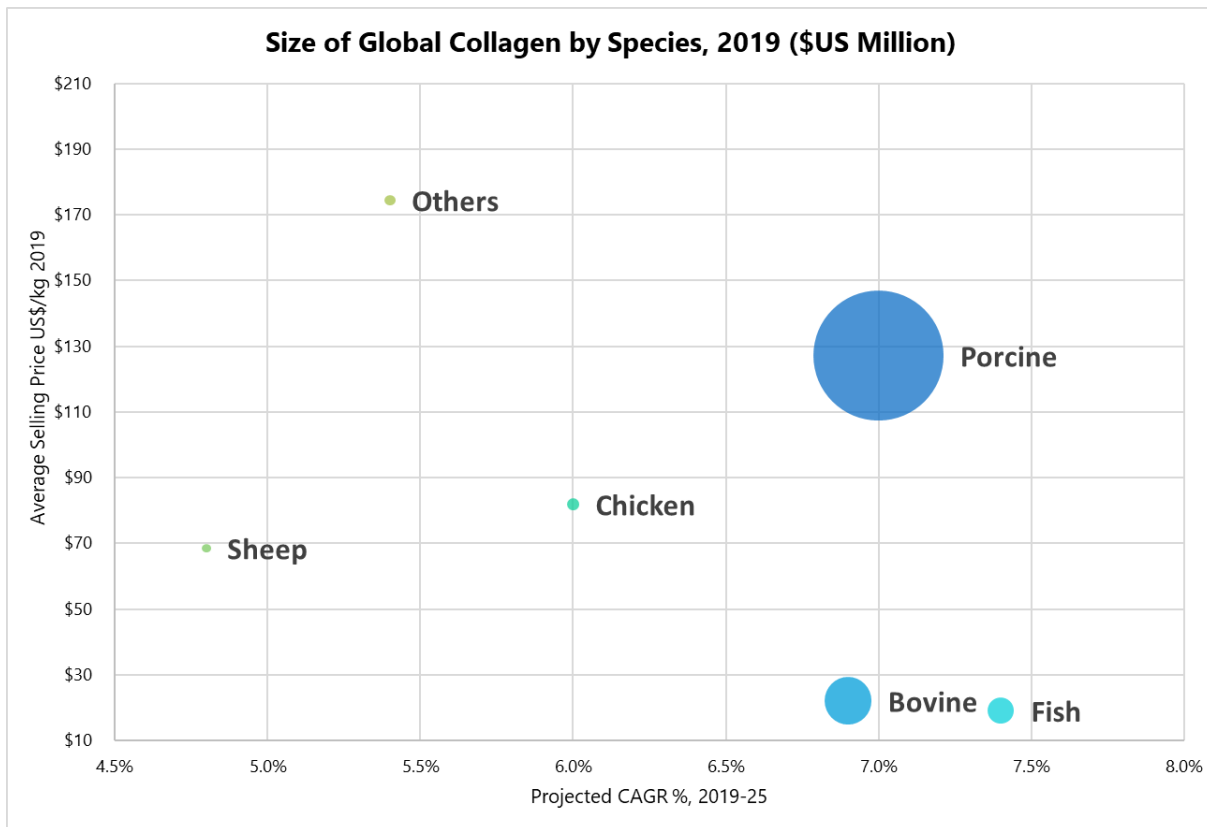


Figure 1. Size of global collagen market by species, 2019 (\$US million) Source: (Meticuous Research Analysis, 2020)

With collagen an emerging but rapidly growing market, and the beef cattle herd size globally, there is significant growth potential for bovine sourced collagen. As displayed in Figure 2, the US is the largest bovine collagen market at present with an expected CAGR of 6.9% and an average selling price of USD\$25/kg in 2019 (Meticuous Research Analysis, 2020). The greatest growth however is expected to come from India and China (Meticuous Research Analysis, 2020).

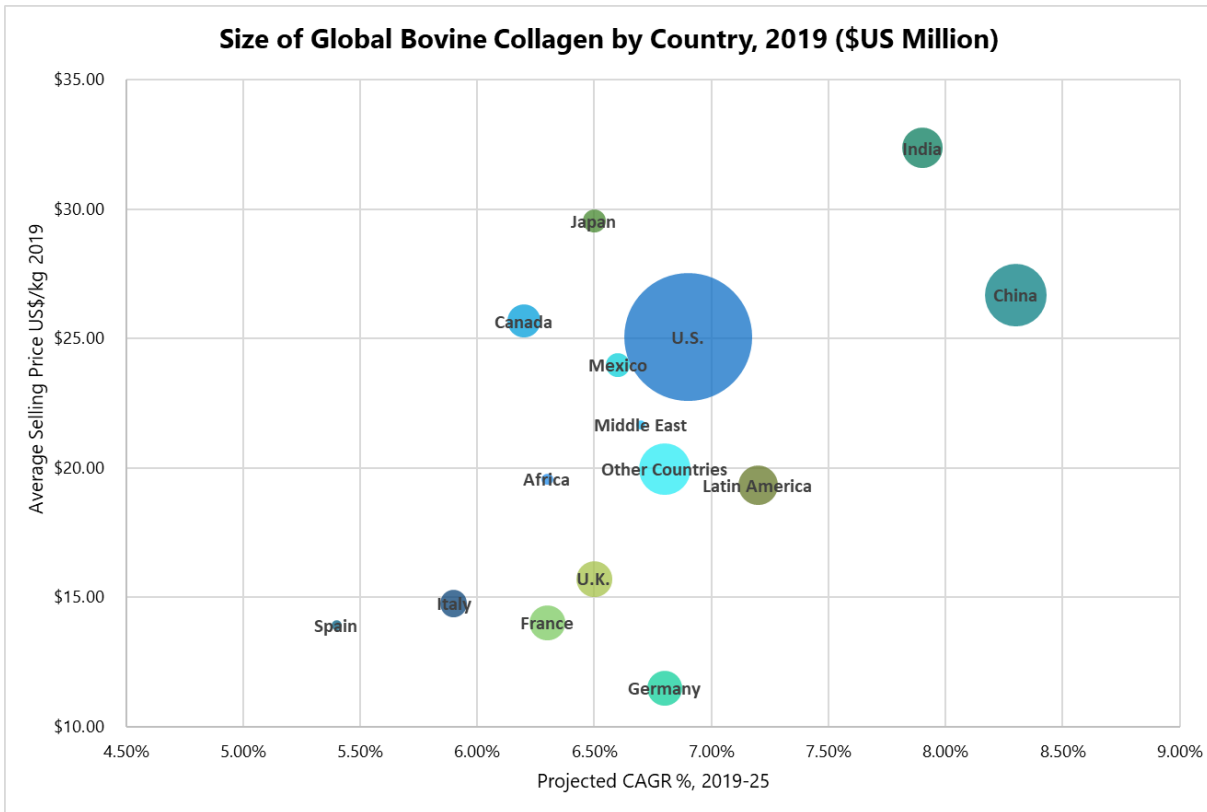


Figure 2. Size of global bovine collagen by country, 2019 (\$US million) Source: (Meticuous Research Analysis, 2020)

Analysis of China and India product category mix as displayed in

Table 1 shows a far greater proportion of collagen products being consumed in the food and beverage category and the nutraceutical category (Meticuous Research Analysis, 2020). Traditional medicine and remedy practices and increased cultural awareness of health and wellbeing linkage to diet may be the significant contributing factor to this trend.

Table 1. Global collagen product category market mix across key countries Source: (Meticuous Research Analysis, 2020)

All Collagen source	China Mix	China Value	India Mix	India Value	Germany Mix	Germany Value	USA Mix	USA Value
Food and Beverages	38%	\$49.23	33%	\$47.13	10%	\$4.14	7%	\$8.58
Pharmaceutical	8%	\$12.97	8%	\$13.29	27%	\$18.26	20%	\$33.20
Nutraceuticals	25%	\$35.77	28%	\$44.92	5%	\$2.43	31%	\$39.39
Healthcare	21%	\$100.13	19%	\$102.78	38%	\$72.65	25%	\$111.94
Cosmetics	3%	\$19.19	4%	\$47.03	5%	\$19.56	5%	\$36.22
Technical	6%	\$18.22	8%	\$23.77	16%	\$21.67	11%	\$31.12
Average		\$36.69		\$39.73		\$13.66		\$34.06

Collectively the food and beverage category are expected to have the highest growth globally with a CAGR of 7.6% between 2019 and 2025 (see Table 2) (Meticuous Research Analysis, 2020). It must be recognized that there are numerous sub categories within the food and beverage application. A snap shot of collagen products is displayed in Figure 3 (Meticuous Research Analysis, 2020). China and India have a rapidly growing middle class and it is well documented that with this socio-economic growth, consumption of protein increases (Kapaj, 2017). This is in line with the extreme growth expectation of the dairy category as consumers purchase more processed dairy products such as cheese, flavoured and fortified milks and yoghurts (Kapaj, 2017).

Table 2. Global collagen market size, by application, 2017-2025 (\$US million). Source: (Meticuous Research Analysis, 2020)

Application	2017	2018	2019	2025	CAGR (2019-2025)
Food & Beverages	1,021.7	1,091.1	1,169.7	1,813.6	7.60%
Pharmaceuticals	792.9	833.8	880.3	1,248.2	6.00%
Nutraceuticals	670.3	711.4	758.1	1,136.3	7.00%
Healthcare	517.9	548.9	584	867.6	6.80%
Cosmetics	125.6	132.4	140.1	201.5	6.20%
Technical (Photography & Ballistic)	213	223.6	235.6	330.3	5.80%

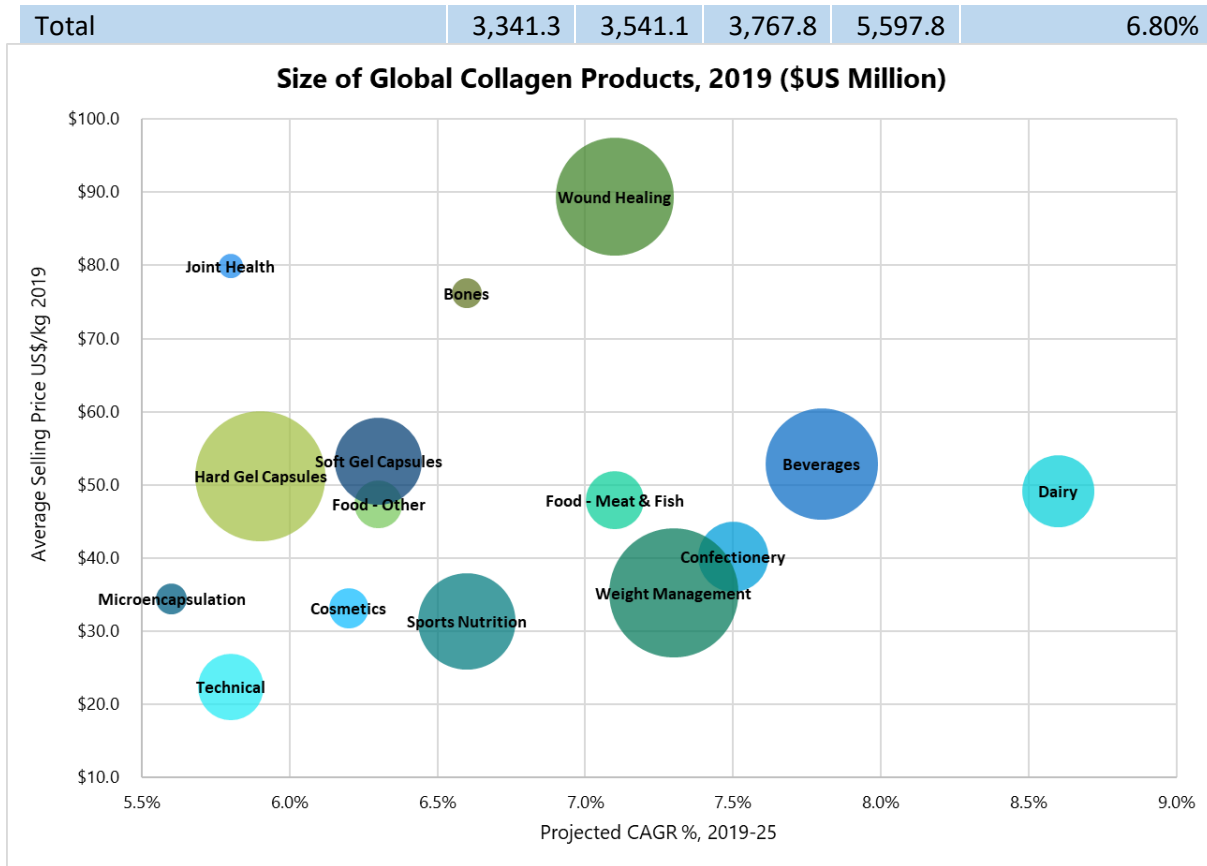


Figure 3. Size of global collagen products, 2019 (\$US million). Source: (Meticuous Research Analysis, 2020)

Market trends & opportunities by category

Food and Beverages

31.0%
of global collagen market

\$1,169.7M
USD (2019)

7.6%
CAGR

\$1,813.6M
USD (2025)

Gelatin is the predominant collagen product utilized in the food and beverage category. It is utilized for its gelling behavior, enabling; texturizing, thickening, gel formation and water binding (Meticuous Research Analysis, 2020). It also aids in surface behavior for; emulsion, foam formation, stabilization, adhesion, cohesion, protective colloidal function and film forming (Meticuous Research Analysis, 2020).

Table 3 presents the market size by region/country for the food and beverage category. The USA is the highest value market and is expected to continue to grow with a CAGR of 7.6% (Meticuous Research Analysis, 2020). The increased consumption of processed foods in China and India and progressively westernized diets will drive high growth in these areas. Religious beliefs constrict the use of both porcine and bovine sources in India however porcine sources are increasingly being approved (Meticuous Research Analysis, 2020).

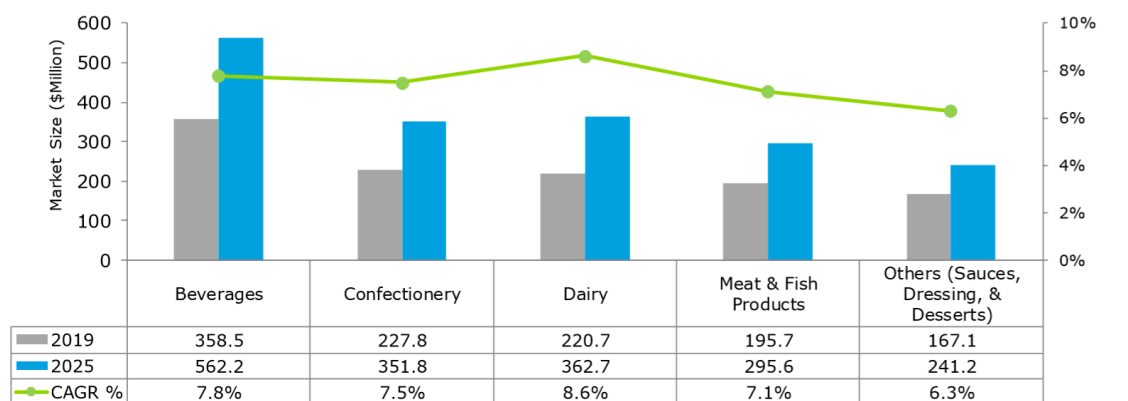
Table 3. Collagen market size for food and beverages, by country/region, 2017-2026 (\$US million). Source: (Meticuous Research Analysis, 2020)

Collagen market size for food and beverages, by country/region , 2017-2026 (\$million USD)

Country/Region	2017	2018	2019	2025	CAGR (2019-2025)
U.S.	256.6	274.0	293.5	455.0	7.6%
Canada	64.3	67.8	71.7	106.4	6.8%
Mexico	44.4	47.4	50.8	77.1	7.2%
Germany	68.0	72.5	77.6	119.8	7.5%
France	70.0	74.1	78.8	117.3	6.9%
U.K.	68.7	73.1	78.0	117.9	7.1%
Italy	47.4	50.1	53.1	77.6	6.5%
Spain	16.7	17.6	18.7	27.0	6.3%
China	93.0	100.9	109.8	184.2	9.0%
India	49.8	54.0	58.7	97.4	8.8%
Japan	33.3	35.6	38.1	58.0	7.3%
Latin America	77.1	83.3	90.2	144.0	8.1%
Africa	27.7	29.3	31.2	47.1	7.1%
Middle East	19.2	20.5	22.1	33.9	7.4%
Other Countries	85.3	91.0	97.5	150.9	7.5%
Total	1,021.7	1,091.1	1,169.7	1,813.6	7.6%

Source: Meticuous Research® analysis

As shown in Figure 4, beverages are the largest application with a global collagen market share of 30.7% (Meticuous Research Analysis, 2020). The beverage market breakdown by country/region as shown in Table 4 expectantly follows a very similar trend to the broader food and beverage category with the US holding the largest market share and China and India demonstrating exceptional growth (Meticuous Research Analysis, 2020).



Source: Meticuous Research® analysis

Figure 4. Food and beverage product breakdown. Source: (Meticuous Research Analysis, 2020)

Table 4. Collagen market size for beverages by country/region, 2017-2025 (\$US million). Source: (Meticuous Research Analysis, 2020)

Collagen market size for beverages by country/region, 2017-2025 (\$million USD)

Country/Region	2017	2018	2019	2025	CAGR (2019-2025)
U.S.	89.6	95.8	102.8	160.0	7.7%
Canada	20.9	22.0	23.3	34.6	6.8%
Mexico	14.9	15.9	17.1	25.8	7.2%
Germany	19.6	20.9	22.4	35.2	7.8%
France	22.8	24.1	25.6	38.1	6.8%
U.K.	23.8	25.3	27.1	41.1	7.2%
Italy	14.8	15.7	16.7	24.8	6.9%
Spain	3.6	3.9	4.2	6.3	7.3%
China	27.7	30.1	32.8	55.2	9.1%
India	11.4	12.5	13.7	23.6	9.5%
Japan	7.4	8.0	8.6	13.6	7.9%
Latin America	19.0	20.7	22.7	38.0	9.0%
Africa	6.7	7.2	7.7	12.1	7.8%
Middle East	4.9	5.3	5.7	9.1	8.0%
Others	24.6	26.3	28.3	44.7	7.9%
Total	311.6	333.6	358.5	562.2	7.8%

Source: Meticuous Research® analysis

Gelatin is often used in low fat products as a replacement to aid in product texture and consistency and hence the high appearance in beverages, sauces/dressings and dairy (Meticuous Research Analysis, 2020). Collagen is increasingly being added to drinks including coffee products, juice and sports drinks (Meticuous Research Analysis, 2020). Collagen enhanced product are being marketed as promoting body collagen production to enhance whole body health including anti-ageing claims (Meticuous Research Analysis, 2020). As such, collagen is often found in beverages alongside other supplements such as Vitamin C and probiotics (Meticuous Research Analysis, 2020). Bovine collagen is the most common source of clarifying agent in beer, wine and juice (Meticuous Research Analysis, 2020). Table 5 outlines key findings on other key subcategories in food and beverages. Dairy, meat and fish and confectionary all demonstrate strong growth potential.

Table 5. Key findings on food and beverage subcategories - Dairy, meat and fish, and confectionary. Source: (Meticulous Research Analysis, 2020)

Dairy	Meat and Fish	Confectionary
<ul style="list-style-type: none">• Dairy production is rapidly increasing with more western diets• Growing populations and changing diets is driving growth in China & India• India 9.7% CAGR• China 10.1% CAGR	<ul style="list-style-type: none">• Limited permits for use – canned and jelly products as a binder• Pork is most common source• Use expected to rise with changing diets• Again China and India lead growth wise with 8.6% and 8.1% respectively	<ul style="list-style-type: none">• Gelatin is the most common food additive in the confectionary industry• Biggest challenge is perceived health issues with consumption of sugar based lollies• China remains a high growth area at 9/.0% CAGR with highest value market being the US at \$56.3M USD

Pharmaceutical

23.4%

of global collagen market

\$880.3M

USD (2019)

6.0%

CAGR

\$1,248.2M

USD (2025)

Collagen is used in the pharmaceutical category to increase the shelf life of medication and to assist with the palatability of medications as it carries flavour well (Meticulous Research Analysis, 2020). Fish gelatin is quite popular in pharmaceuticals as it is free from many of the religious constraints that other sources are subject to (Meticulous Research Analysis, 2020). The US predictably has the largest market share at 24%, however India and China are both predicted to experience high growth in this category as their populations not only increase but the average age of their populations increase as well (Meticulous Research Analysis, 2020).

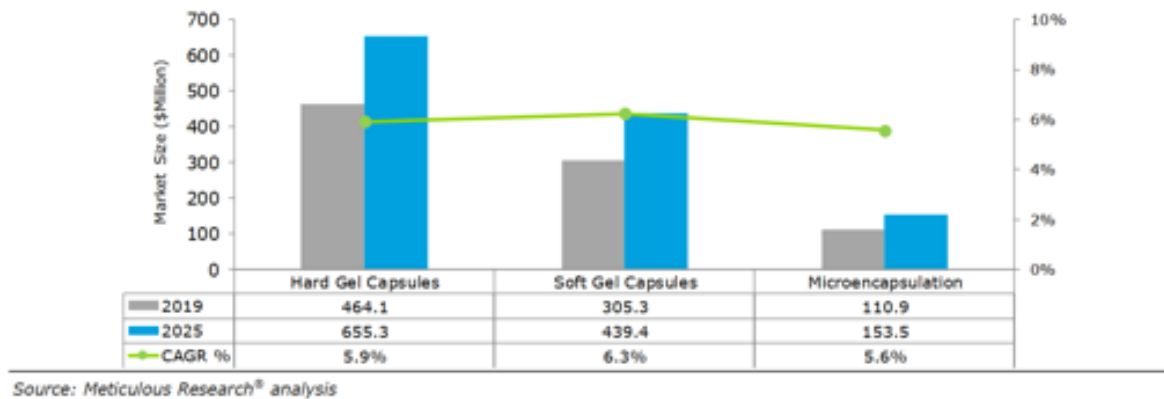
Table 6. Collagen market size for pharmaceuticals, by country/region, 2017-2025 (\$US million) Source: (Meticulous Research Analysis, 2020)

Collagen market size for pharmaceutical, by country/region , 2017-2025 (\$million USD)

Country/Region	2017	2018	2019	2025	CAGR (2019-2025)
U.S.	190.4	200.0	211.0	298.9	6.0%
Canada	43.7	45.4	47.3	64.3	5.3%
Mexico	28.6	30.1	31.8	44.4	5.7%
Germany	53.2	55.8	58.8	82.8	5.9%
France	44.2	46.2	48.4	66.4	5.4%
U.K.	44.6	46.7	49.1	68.1	5.6%
Italy	34.8	36.2	37.8	50.4	4.9%
Spain	15.2	15.8	16.5	21.5	4.5%
China	75.7	80.8	86.6	133.0	7.4%
India	49.0	52.2	55.8	83.6	7.0%
Japan	29.2	30.7	32.3	44.7	5.6%
Latin America	73.8	78.3	83.3	120.0	6.3%
Africa	24.4	25.4	26.6	36.5	5.4%
Middle East	16.9	17.8	18.8	26.2	5.7%
Other Countries	68.9	72.3	76.2	107.4	5.9%
Total	792.9	833.8	880.3	1,248.2	6.0%

Source: Meticulous Research® analysis

As shown in Figure 5, hard capsules are the most prevalent subcategory of pharmaceuticals (Meticulous Research Analysis, 2020). Echoing the growing use of medications and supplements with ageing populations across the globe. It must be recognized however that this is an established market with many established players.



Source: Meticulous Research® analysis

Figure 5. Sub-categories for pharmaceuticals. Source: (Meticulous Research Analysis, 2020)

Nutraceuticals

20.1%

of global collagen market

\$758.1M

USD (2019)

7.0%

CAGR

\$1,136.3M

USD (2025)

Sports nutrition has always been important to professional athletes however there is an increasing consumer trend among the general population of sports supplements for gym goers and weekend amateur athletes (Meticulous Research Analysis, 2020). Nutraceuticals is primed to harness this market and coupled with weight management options, nutraceuticals is a rapidly growing category. It is estimated that 30% of the world's population, or 2.1 billion people, are considered obese and research has shown collagen peptides are effective at assisting weight management (Meticulous Research Analysis, 2020). In fact as Figure 6 shows, weight management accounts for the largest proportion of the nutraceutical market share (Meticulous Research Analysis, 2020).

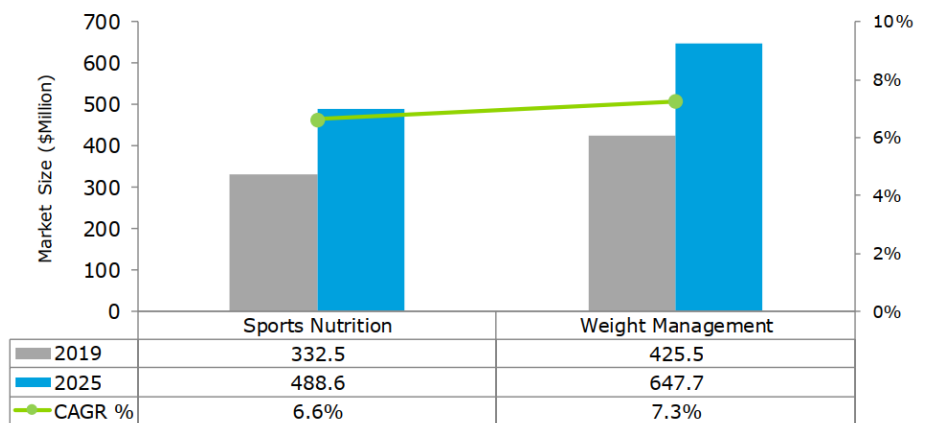


Figure 6. Nutraceutical subcategories market shares. Source: (Meticulous Research Analysis, 2020)

The US remains the dominant market however emerging economies with growing wealth, disposable income, and access to social media, will experience rapid growth (see Table 7) (Meticulous Research Analysis, 2020).

Table 7. Collagen market size for nutraceuticals, by country/region, 2017-2025 (\$US million). Source: (Meticuous Research Analysis, 2020)

Collagen market size for nutraceuticals, by country/region , 2017-2025 (\$million USD)

Country/Region	2017	2018	2019	2025	CAGR (2019-2025)
U.S.	148.3	157.4	167.6	251.2	7.0%
Canada	39.1	41.0	43.1	62.0	6.3%
Mexico	28.2	29.9	31.9	47.2	6.7%
Germany	50.1	53.1	56.4	84.1	6.9%
France	50.1	52.8	55.8	81.1	6.4%
U.K.	41.8	44.2	46.9	68.9	6.6%
Italy	28.3	29.7	31.3	44.3	5.9%
Spain	13.1	13.8	14.5	20.0	5.5%
China	62.6	67.5	73.0	118.6	8.4%
India	42.6	45.9	49.5	78.6	8.0%
Japan	25.3	26.8	28.5	41.8	6.6%
Latin America	51.1	54.7	58.8	89.7	7.3%
Africa	19.2	20.2	21.3	31.0	6.4%
Middle East	13.4	14.3	15.2	22.5	6.7%
Other Countries	56.7	60.2	64.0	95.4	6.9%
Total	670.3	711.4	758.1	1,136.3	7.0%

Source: Meticuous Research® analysis

Healthcare

15.5%

of global collagen market

\$584M

USD (2019)

6.8%

CAGR

\$867.6M

USD (2025)

Continual advancements in collagen processing has seen it become a key part of health care (Meticuous Research Analysis, 2020). Bovine collagen has been the major source of collagen for healthcare due to its compatibility with human tissues, however outbreaks and risk of BSE, TSE and FMD have seen researchers look for alternative solutions (Meticuous Research Analysis, 2020).

Wound healing has the largest market share of the healthcare subcategories at 67.1% (Meticuous Research Analysis, 2020). As research has continued and medical techniques advanced, there has been an increased demand for advanced wound healing, driving an increased demand for collagen wound healing products (Meticuous Research Analysis, 2020).

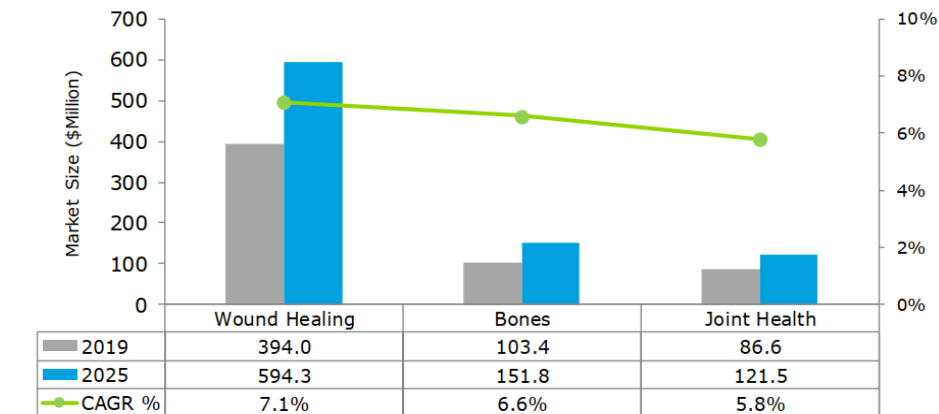


Figure 7. Subcategories of healthcare. Source: (Meticulous Research Analysis, 2020)

Table 8 shows the market size by region/country for healthcare collagen, with the US again holding the largest market size (Meticulous Research Analysis, 2020). High growth is expected across the globe echoing trends observed up until now.

Table 8. Collagen market size for healthcare, by country/region, 2017-2025 (\$US million). Source: (Meticulous Research Analysis, 2020)

Collagen market size for healthcare, by country/region , 2017-2025 (\$million USD)

Country/Region	2017	2018	2019	2025	CAGR (2019-2025)
U.S.	119.7	126.8	134.9	200.4	6.8%
Canada	28.0	29.3	30.8	43.9	6.1%
Mexico	22.0	23.3	24.8	36.3	6.6%
Germany	37.3	39.4	41.8	61.8	6.7%
France	37.8	39.8	42.1	60.6	6.3%
U.K.	32.1	33.9	35.9	52.2	6.4%
Italy	24.4	25.6	26.9	37.6	5.8%
Spain	10.9	11.4	11.9	16.3	5.4%
China	51.8	55.7	60.2	97.0	8.3%
India	28.4	30.5	32.9	51.8	7.8%
Japan	17.7	18.7	19.8	28.8	6.4%
Latin America	41.3	44.1	47.3	71.5	7.1%
Africa	15.7	16.5	17.4	25.0	6.2%
Middle East	9.8	10.4	11.1	16.2	6.6%
Other Countries	41.1	43.5	46.2	68.2	6.7%
Total	517.9	548.9	584.0	867.6	6.8%

Source: Meticulous Research® analysis

Cosmetics

3.7%

of global collagen market

\$140.1M

USD (2019)

6.2%

CAGR

\$201.5M

USD (2025)

Collagen has long found a home in the cosmetics industry with natural collagen production declining from approximately age 25 years (Meticulous Research Analysis, 2020). This decline leads to a loss of skin substance resulting in signs of ageing (Meticulous Research Analysis, 2020). Reductions in natural collagen also results in hair loss. Collagen can be added into cosmetics to supplement the synthesis of collagen and with growing and ageing populations with increasing amounts of disposable income and social media exposure, this market will continue to boom (Meticulous Research Analysis, 2020).

Table 9 shows the market share of collagen in cosmetics with the US once again dominating market share (Meticulous Research Analysis, 2020). Whilst there is significant growth forecasted for the cosmetic category, it must be acknowledged that this category is dominated by large cosmetic brands.

Table 9. Collagen market size for cosmetics, by country/region, 2017-2025 (\$US million). Source: (Meticulous Research Analysis, 2020)

Collagen market size for cosmetics, by country/region , 2017-2025 (\$million USD)

Country/Region	2017	2018	2019	2025	CAGR (2019-2025)
U.S.	25.1	26.5	28.0	40.7	6.4%
Canada	12.6	13.1	13.7	19.1	5.7%
Mexico	7.2	7.6	8.1	11.5	6.1%
Germany	7.3	7.7	8.1	11.8	6.3%
France	9.3	9.8	10.3	14.5	5.8%
U.K.	13.4	14.1	14.9	21.2	6.0%
Italy	6.4	6.7	7.0	9.6	5.4%
Spain	3.3	3.5	3.7	4.9	4.9%
China	6.4	6.8	7.4	11.6	7.8%
India	6.0	6.4	6.8	10.5	7.4%
Japan	4.9	5.2	5.5	7.8	6.0%
Latin America	8.6	9.2	9.8	14.5	6.7%
Africa	4.1	4.3	4.5	6.4	5.8%
Middle East	2.1	2.2	2.3	3.3	6.2%
Other Countries	8.9	9.4	9.9	14.3	6.3%
Total	125.6	132.4	140.1	201.5	6.2%

Source: Meticulous Research® analysis

Technical

6.3%

of global collagen market

\$235.6M

USD (2019)

5.8%

CAGR

\$330.3M

USD (2025)

Technical uses for collagen include more than just glue with photography, ballistics and paper also occupying this space (Meticuous Research Analysis, 2020). Gelatin has made photography affordable with its application in film and glossy paper coatings (Meticuous Research Analysis, 2020). Collagen when processed correctly can be formed into blocks that replicates the density of human tissue, therefore making it useful for ballistics (Meticuous Research Analysis, 2020).

Table 10 shows the US are again the largest market for technical collagen (Meticuous Research Analysis, 2020). The technical category is quite niche in some areas and commoditized in others, and subsequently has the lowest average value and lowest forecasted growth rates (Meticuous Research Analysis, 2020).

Table 10. Collagen market size for technical, by country/region, 2017-2025 (\$million US). Source: (Meticuous Research Analysis, 2020)

Collagen market size for technical, by country/region , 2017-2025 (\$million USD)

Country/Region	2017	2018	2019	2025	CAGR (2019-2025)
U.S.	54.8	57.5	60.5	85.0	5.8%
Canada	11.4	11.9	12.3	16.6	5.1%
Mexico	6.3	6.6	7.0	9.6	5.6%
Germany	16.0	16.7	17.6	24.6	5.7%
France	10.2	10.6	11.1	15.1	5.3%
U.K.	12.2	12.8	13.4	18.4	5.4%
Italy	10.5	10.9	11.3	15.0	4.8%
Spain	4.4	4.5	4.7	6.1	4.4%
China	13.9	14.9	15.9	24.2	7.2%
India	13.0	13.8	14.8	22.0	6.8%
Japan	6.7	7.1	7.4	10.2	5.4%
Latin America	22.0	23.3	24.8	35.4	6.1%
Africa	6.8	7.0	7.3	10.0	5.2%
Middle East	3.7	3.9	4.1	5.7	5.6%
Other Countries	21.1	22.1	23.2	32.4	5.7%
Total	213.0	223.6	235.6	330.3	5.8%

Source: Meticuous Research® analysis

Collagen market players

Desktop research has shown that there are several large players in the collagen market (Meticuous Research Analysis, 2020). The majority of them operate in the food and beverage category and the pharmaceutical category (Meticuous Research Analysis, 2020). These are the most mature and largest categories by size. Nutraceuticals, healthcare, cosmetics and technical have specialized market players, suggesting specialized processing techniques and more vertical supply chains (Meticuous Research Analysis, 2020).

Table 11. Snapshot of major collagen market players. Source: (Meticuous Research Analysis, 2020)

Name	Based	Sales	Growth Rate	Food & Beverages	Pharmaceuticals	Nutraceuticals	Healthcare	Cosmetics	Technical
Rousselot	Netherlands	33,857.7	-7.50%	Y	Y	Y	Y		Y
Gelita	Germany	822.0	2.60%	Y	Y	Y	Y		
Weishardt	France	Privately Held		Y	Y				Y
Tessengerlo	Belgium	1,914.3	2.20%	Y					
Nitta Gelatin	Japan	333.5	-2.50%	Y	Y	Y	Y	Y	Y
Lapi Gelatine	Italy	Privately Held		Y	Y				
Italgelatine	Italy	Privately Held		Y	Y				Y
Ewald-Gelatine	Germany	Privately Held		Y					
Reinert Group Ingredients	Germany	Privately Held		Y					
Trobas Gelatine	Netherlands	Privately Held		Y	Y				
Gelnex	Brazil	Privately Held		Y	Y				
Juncà Gelatines	Spain	Privately Held		Y	Y				
Holista Colltech	Australia	7.9	5.30%	Y		Y			
Collagen Solutions	Scotland	5.7	16.20%				Y		
Advanced Biomatrix	US	Privately Held					Y		

Domestically, there are a few processors of collagen with a public presence. These are:

- Holista Colltech, based in WA
 - They have a market in Malaysia for Bovine collagen, recently branching out into monopolistic ovine collagen markets
 - They also possess a patent for ovine collagen production
 - <https://www.holistaco.com/>
- GelPro, based in NSW with 216 stockists Australia-wide
 - It is unclear if they produce the raw collagen themselves, or are on-sellers
 - Centered on nutraceuticals and supplements
 - <https://www.gelatinaustralia.com.au/>
- Gelita, based in Beaudesert QLD
 - Producing gelatin and collagen peptides, as well as other by-products, they deal in a hide-to-retail production line
 - Products range from food and nutraceuticals to pet and livestock feeds, fertilizer and technical applications.
 - One of the most likely partners for collagen production given company profile and proximity to ACC
 - <https://www.gelita.com/en>
- Maverick Biosciences, based in Dubbo NSW
 - They produce collagen from a wide range of bovine and other animal sources as well as numerous bioactive compounds
 - Medical grade production line with international market
 - Another quite likely partner for ACC due to production range
 - <http://maverickbio.com/>

Further, there are many domestic retailers of collagen. It is unclear whether they process hides themselves, or source it externally. The processing of hides, as a market, is poorly documented. This may be due, in part, to the wide availability of hides so a processor can pick and choose where they

source hide from. On the retail side, it may be due to a desire to pick the retail channels they sell through. Despite this lack of transparency, it is clear that collagen ‘creators’ are available, due to the extensive retail presence of collagen powders and derivative products. The question remains, whether the collagen is produced by the retailer, in an abattoir-to-retailer market, or by another party in an abattoir-to-processor-to-retailer market.

If a processor of hides chose to produce collagen themselves, they may package it through a company like Morlife, who deal in white label services in powder and liquid blending for nutraceutical and supplement products, as well as retail packaging. Morlife are based in Arundel QLD. <https://morlife.com/>

Collagen manufacturing and value

There are 16 types of collagen. Type I, II and III can be extracted from bovine raw materials. As shown in Figure 8, different types of collagen can be extracted from different components of the bovine body.

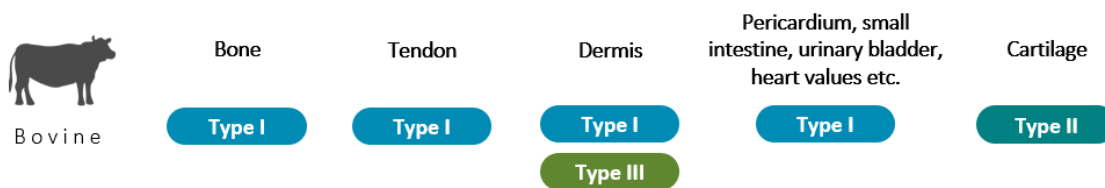


Figure 8. Collagen types against bovine raw material source

There are four primary collagen production processes (see Figure 9):

- Thermoplastics
- Gelatin
- Short chain collagen
- Long chain dialysed collagen

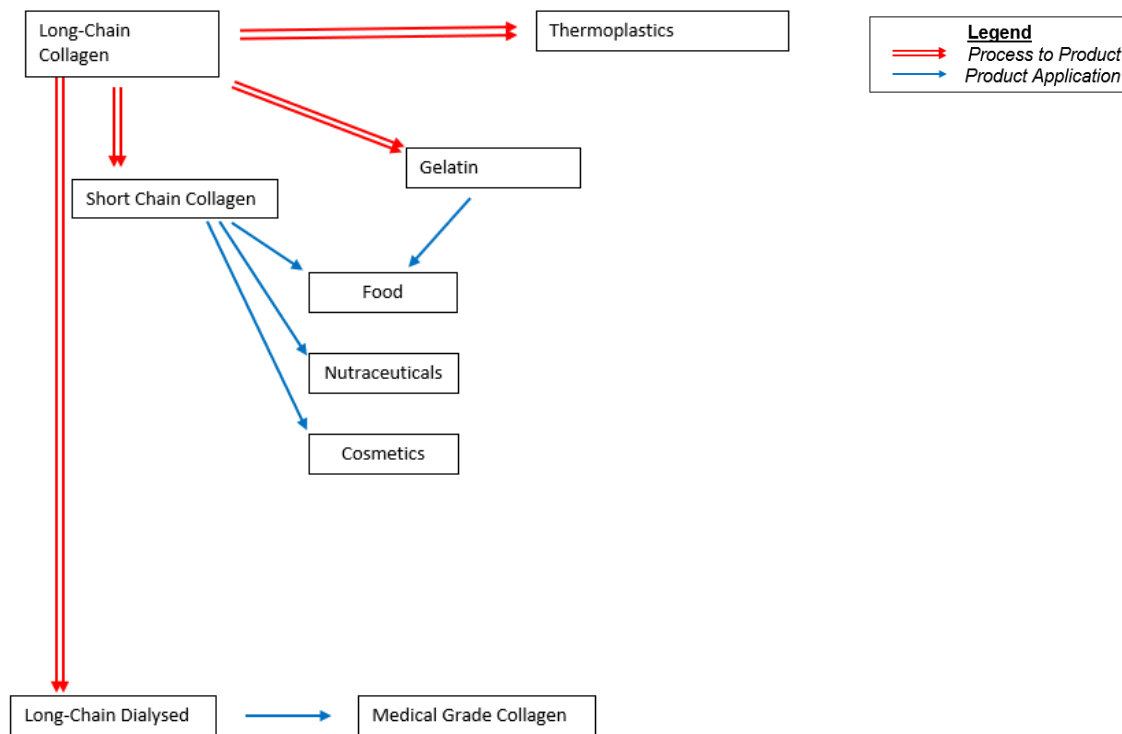


Figure 9. Collagen production processes with applications

Raw product processing

There is limited available information on current operational equivalent systems in Australia. This will mean a review of overseas operations, which are often difficult to replicate in Australia due to different labour, regulatory and commercial environments.

A recent presentation from the *Wastes to Profits* project outlined the potential to produce commercially ready products derived from waste by-products (Gianini, 2010). It presents approaches to value-adding waste and by-products from hides. One such approach is a sequential biorefinery process that produces multiple types of hide waste-derived by-products. The by-products they list includes collagen, keratin, fat, melanin, and glycoaminglycans. The approach would replace tanning processes from the soaking stage of production, and so would be suitable to an organisation that supplies salted or green hides, such as ACC.

The presentation is light on specific processes that would lead to the extraction and purification of these by-products, and is therefore a focus area of this research. The methods, their required equipment, supplies, required accreditation or training, associated management, and the product yield from it are all to be considered.

The *Waste to Profits* project has outlined a production process for hide by-products that could sequentially lead to the production of GAG, keratin and melanin, in addition to collagen from leftover hide or trim. Methods of extraction and purification are briefly mentioned in the presentation and were explored deeper as part of this reports research. It must be noted that only the market potential for collagen has been determined as the others were considered out of scope for this project.

Hide material collection

Pre-tanning processes that could yield potentially useful waste by-products include the liming, trimming and fleshing stages. Some form of these stages are already needed to produce collagen by-products, so establishing them as part of the production process could help yield additional by-products. Liming stages can produce hair for keratin production, trimming can produce both fleshed and unfleshed trim for use in collagen, melanin and chondroitin acid production (Hashem, 2015). Fleshing can produce a significant amount of fat and protein, with one study estimating approximately 200-400kg of fleshing by-product out of 1000kg of green or salted hides (Hashem, 2015; Lupo, 2006). Some of these fats could be rendered into tallow using existing processes, while the protein could be used to produce collagen, chondroitin acid and hyaluronic acid.

Liming requires large scale drums, along with the solutions for liming. These can include caustic soda, sodium sulphate, lime, and bactericides. There are some proprietary enzymatic solutions available internationally that can replace the caustic soda, sodium sulphate and lime and allow for the hair to be retained and processed into keratin afterwards (Quimser, 2017). Both methods would also need waste processes mapped out.

Fleshing can be achieved manually or semi-automatically. Manual fleshing requires much of the same processes as trimming and would require the same equipment as trimming. Fleshing machines provide a semi-automatic approach, still requiring a degree of labour and training to use.

Trimming is still a manual process. A labourer spot checks the hide for condition deformities and, using a knife, would trim parts off the hide. Equipment need would include the trimming knife, the knife sharpening station, a collection tub or bucket for the trim, and cleaning stations.

Collagen

Broadly, the methods for collagen extraction involve preparation of the hide, such as dehairing and mechanically breaking down the hide, followed by progressive and repeated steps of enzymatic hydrolysis, chemical hydrolysis or both, and separating the collagen from the solution through centrifugation or precipitation with alcohol (Gianini, 2010; Dahm, 2011; Meyer, 2019; Mohammad, 2014). Each step can take hours or days to complete, and need controls for temperature and pH. The exact processes used depends on the end product desired. The figure below from Meyer (2019) helps visualise this (Figure 10) .

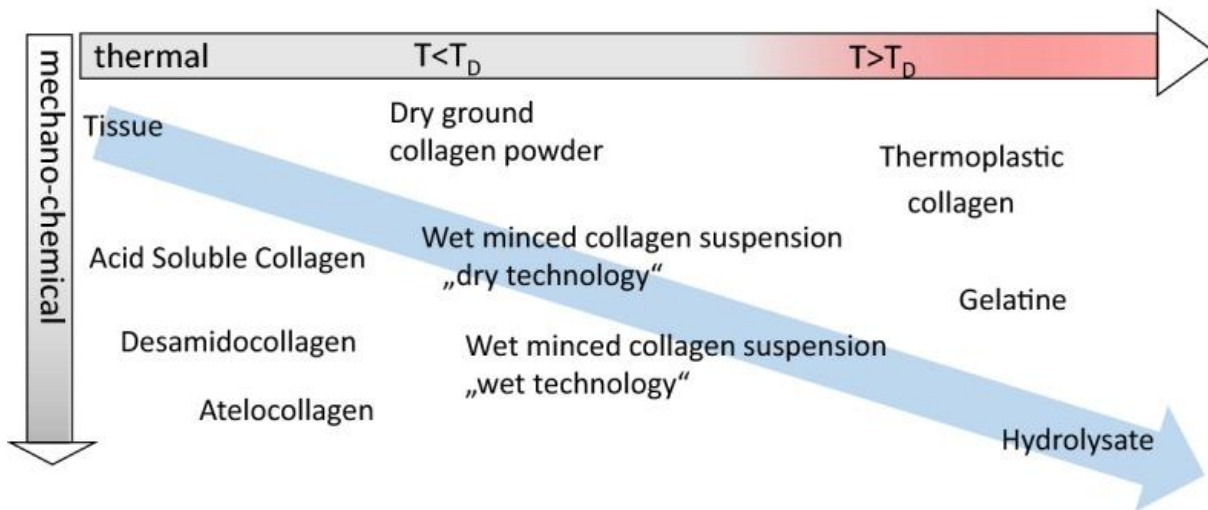


Figure 10. Degree of method types required to produce collagens fit for different products (Meyer, M 2019). TD stands for the denaturation temperature, or the temperature at which collagen begins to breakdown

If you want to create collagen supplements, then you would aim for producing hydrolysate, or hydrolysed collagen. Maintaining the molecular structure isn't as important for a product like this, so high concentrations of acid or alkaline and high temperatures can be used. However, biomedical or pharmaceutical applications could require Dry ground collagen powder, Acid soluble Collagen or either of the Wet Minced suspensions, depending on the customer's needs. Maintaining the structure becomes more important in these applications, and so enzymatic hydrolysis and near-zero temperatures are used instead (Dahm, 2011; Meyer, 2019; Noorzai, 2019).

Equipment for collagen extraction and purification includes:

- Containers that can provide continuous movement or mixing.
- Temperature regulation: near-zero refrigeration, room temperature, body temperature (37°C), or denaturation temperature, depending on desired product.
- Probes for temperature and pH.
- Acid or Alkaline solutions
- Enzyme solutions, specifically porcine-derived peptin.

Most processes for extraction are not automated, so likelihood of purchasing machinery that automates or semi-automates is low.

Skill set requirements

Australian Country Choice currently has a wide skill set that applies to all aspects of livestock production and processing through to retailer ready value-added products. This includes all the support skill sets such as operational, management, and engineering and maintenance supervision.

The skill set requirements for processing base biological material through to producing valuable, bulk, pharmaceutical-grade materials are very different from the current Australian Country Choice skill sets.

Some of the skill set areas that need to be considered are:

1. Pharmaceutical grade processing skill sets.
2. Pharmaceutical quality assurance and regulatory compliance skill sets.

3. Pharmaceutical warehouse and logics management skill sets.
4. Pharmaceutical manufacturing environment engineering and maintenance skill set.
5. International pharmaceutical raw material marketing and sales skill sets.
6. Operational management skill set for pharmaceutical manufacturing.

Many of the above skills sets and applicable qualifications can only be obtained through working in similar pharmaceutical manufacturing environments. Australian Country Choice would need to obtain these necessary skill sets to undertake the activities for base biological material processing through to producing valuable, bulk, pharmaceutical-grade materials. These pharmaceutical manufacturing skill sets may not be readily available from within the Brisbane employment pool.

Customer and regulatory compliance considerations

The process of taking base biological material and producing valuable bulk pharmaceutical grade materials out of them will likely require considerable and complex customer and regulatory compliance approvals. Some of these compliance outcomes might take several years to obtain. This is because the history for production data and history of production material analysis results can form part of the compliance approvals. In other words, the pharmaceutical manufacturing facility needs to have produced enough product over a long enough period to demonstrate compliance to the requirements to obtain necessary approvals.

Consideration will need to be given on how to commercially manage the process of customer and regulatory compliance approvals that could potentially take a long time to obtain. This might mean that product may need to be sold to a lower value market until the necessary approvals are obtain.

Product value

Desktop research of the Alibaba marketplace has found the commodity collagen prices. This is processed but not value-added collagen. Prices are shown in Table 12 and indicate a lower commodity price for hide derived collagen. This may be due to the abundance and low raw material price of hides, the lower manufacturing costs, and the lower quality final commodity product when compared to medical grade.

Table 12. Commodity collagen prices from Alibaba marketplace

Product	Bovine source	Application	Price
Undenatured collagen	Cartilage		US\$15.00/kg
Atelocollagen	Type I	Medical grade	US\$50,000/kg
Fibrillar telocollagen	Type I	Medical grade/research	US\$5,000/kg
Gelatin	Hide		US\$2.50/kg
	Bone		US\$4.60/kg
Hydrolysed collagen	Hide		US\$4.00/kg
	Bone		US\$12.00/kg
	Cartilage		US\$80.00/kg

Desktop research of online marketplaces has shown the considerable margin to be gain from further processing or value adding (see Table 13).

Table 13. Collagen end product online marketplace pricing

Category/Application	Product	Price
Medical	Tooth wound dressing	US\$0.9/pc
	Sponge wound dressing	US\$10/pc
	Dental membrane	US\$15/pc
Gelatin	Leaves	US\$10.6/kg
Hydrolysed collagen powder	Bulk	AU\$52/kg
	Supplement	US\$63/kg
	Joint Care	AU\$132/kg
	Sports Nutrition	AU\$176/kg

Healthcare value chain analysis

Analysis of the healthcare category and the potential for hide collagen in the value chain is significant. Hide collagen with an end product of Fibrillar telocollagen for medical and research purposes has a potential of 1.6MT and AUD\$4.2M pa based on utilising 1k Hides. Table 14 breaks down the key estimated cost components with associated margins. Cells highlighted in orange are assumptions only however show a potential \$2,602/kg of additional margin if it is taken to be a retail product. Sensitivity analysis based on the value of hides indicate the range of profit potential is from \$4.1M to \$4.2M based on hide valuations from \$70/hide to \$0/hide.

Table 15. Value chain analysis of hide collagen for Atelocollagen

Hide Collagen - Atelocollagen				
Processor- Retailer Sales Margin				
Raw Material Pricing (\$/kg)		\$	16.25	
Normal Margin (\$/kg)	5%	\$	0.81	
Additional Packing & Labour costs (\$/kg)				
Additional Processing costs (\$/kg)		\$	166.67	
Transport Cost (\$/kg)		\$	0.16	
Value Add Costs (\$/kg)		\$	20.00	
Transfer Price (\$/kg)		\$	203.89	
Price to Manufacturer		\$	32,568.78	
Manufacturing Costs (\$/kg)		\$	500.00	
Marketing costs (\$/kg)				
Price to Distributor		\$	33,068.78	
Distributor Margin	40%	\$	13,227.51	
Distributor Sell Price (\$/kg)		\$	46,296.30	
Price to Retailer		\$	46,296.30	
Mark-up	50%	\$	23,148.15	
Retailer Sell Price (\$/kg)		\$	69,444.44	
Additional Processors Margin	15874%	\$	32,364.89	
Total Margin (\$/kg)	15874%	\$	32,365.70	
			\$20/hide	\$0/hide
Kgs per Annum			476	476
Hides used			306	306
Profit per Annum		\$	15,398,108	\$ 15,406,136
Break Even CAPEX Cost for 10yrs @ 15% IRR		\$	77,279,542	\$ 77,319,834

Nutraceuticals value chain analysis

Similar value chain analysis was conducted on hide collagen for nutraceuticals. Potential was found for 264MT pa and \$3.9M pa based on utilising 110,000 hides. Process breakdown as shown in Table 16 estimates a total margin of \$14.89/kg if taken to retail. Sensitivity analysis based on the value of hides indicate the range of profit potential is from -\$3.3M to \$6.8M based on hide valuations from \$70/hide to \$0/hide.

Table 16. Value chain analysis of hide collagen for nutraceuticals

Hide Collagen - 1kg Collagen Powder				
Processor- Retailer Sales Margin				
Raw Material Pricing (\$/kg)		\$	10.54	
Normal Margin (\$/kg)	5%	\$	0.53	
Additional Packing & Labour costs (\$/kg)		\$	1.97	
Additional Processing costs (\$/kg)		\$	1.57	
Transport Cost (\$/kg)		\$	0.16	
Transfer Price (\$/kg)		\$	14.77	
Marketing costs (\$/kg)				
Price to Manufacturer		\$	29.67	
Manufacturing Costs (\$/kg)		\$	10.00	
Marketing costs (\$/kg)		\$	2.00	
Price to Distributor		\$	41.67	
Distributor Margin	40%	\$	16.67	
Distributor Sell Price (\$/kg)		\$	58.33	
Price to Retailer		\$	58.33	
Mark-up	50%	\$	29.17	
Retailer Sell Price (\$/kg)		\$	87.50	
Additional Processors Margin	101%	\$	14.89	
Total Margin (\$/kg)	104%	\$	15.42	
			\$20/hide	\$0/hide
			\$70/hide	
Kgs per Annum			263,967	263,967
Hides used			110,101	110,101
Profit per Annum		\$	3,931,214	\$ 6,821,369
Break Even CAPEX Cost for 10yrs @ 15% IRR		\$	19,729,853	\$ 34,234,871
				-\$ 3,294,173
				-\$ 16,532,694

7.0 CONCLUSIONS/RECOMMENDATIONS

Bovine hides are currently worth less than US\$30/head (MLA, 2020) with market trends showing consumers moving away from leather as a regular textile. This accompanied by increased regulation on hide processing in China has reduced the hide leather market share. Hide collagen is a direct market alternative and is estimated at on average across categories to be worth US\$37/head and is accompanied by strong growth in demand across many product categories.

Findings of this project have informed the recommendation of further work to uncover the opportunities presented in the healthcare and nutraceutical categories for bovine hide collagen. Research into healthcare has shown that it is continually present in the higher value segments of the collagen market. Australia has a differentiating and competitive advantage with its BSE and FMD free status and hence can offer a high biocompatibility collagen product for use in human grade products. There are challenges in the healthcare collagen market with a significant time to market, high capital costs and development timelines to develop suitable end products, and some large and sophisticated collagen processors with patents and significant market penetration. Greenleaf therefore recommends that ACC investigates finding partners with the specialized skills and expertise to add value to high quality raw material to enter the healthcare category.

Research into nutraceuticals has shown that it is a growing segment of the market that is unlikely to slow down in the short or medium terms. Nutraceuticals are an ideal accompaniment to the ACC brand with family values and clean, green image. Again, Australian bovine presents as a value disease free product that differentiates itself from competitors. Challenges in nutraceuticals include that it is a very competitive space with both large players and numerous small opportunistic players trying to benefit from the significant market growth. Whilst nutraceuticals is not the highest value category there is significant potential in growing markets such as China and India and the increased health focus as a result of COVID-19 will only improve opportunities. Greenleaf recommends that ACC use nutraceuticals as the point of entry into the collagen market with an initial level of value adding through bulk collagen powders. This enables ACC to value-add bovine hides and reduce the number of hides entering rendering. There are also potential opportunities to partner with other processors for added volume.

There are a few possible business models to commercially achieve the objective of commercial products derived from Hide Collagen. These business models include:

1. Purchasing a commercial business that currently takes raw material from slaughter processing facilities. ACC would move that commercial business to the Australian Country Choice Cannon Hill facility and expand the business, building on the volume of hides available through the processing facility already onsite and the existing technical, operational and commercial relationship for the existing business.
2. Partner with an existing major consumer of Hide Collagen processed products to develop partner-specific processes and products to fulfill the commercial partner requirements. This has the advantage of a ready market for the products, as well as the available expertise on the technical requirements of the production processes. Australian Country Choice would grow the operational and technical expertise in the product area while ensuring a commercial demand throughout the learning phase.
3. Partner with one or more universities with Australian Country Choice, providing the commercialisation and commercial production scale facility for the research outcomes. This model takes research that has demonstrated commercial value from the universities and upscales it to commercial volumes using Australian Country Choice facilities and onsite, available hides.

It is not likely that Australian Country Choice, as an organisation, could readily obtain all the necessary technical, operational, commercial and regulatory knowledge and expertise required for processing hide collagen by-products into valuable commercial products without major external assistance through one of the above models. To pursue entry into collagen, contact with Gelita is recommended, given proximity to Brisbane, and completeness of value chain handling. This would allow entry in the nutraceutical market. Additional safety and traceability measures are required to harness the medical market, however the lucrative margins warrant further investigation by ACC through contact with Maverick Biosciences in Dubbo NSW. An alternative would be partnership with a range of companies. For example, a company to process the hides into collagen, Morlife to package it, and GelPro to use their brand for sale.

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