Final report

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Proof of Concept Study: Investigation of the Feasibility and Viability of Freeze-dried Bovine Blood Products (FD-BBP) as Functional Food and Nutraceutical Ingredients.

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Abstract

This proof-of-concept project investigates the feasibility and viability of utilising freeze-dried bovine blood products (FD-BBP) as functional food and nutraceutical ingredients. This project aimed to explore the potential of bovine blood, a significant yet underused resource, as a high-protein, bioavailable iron supplement for functional foods targeting aging populations and individuals with iron deficiencies. The methodology involved collecting bovine blood from a Tasmanian abattoir, followed by freezing and freeze-drying at a Tasmanian freeze-drying facility. Food safety testing was conducted at the University of Tasmania and a commercial food testing laboratory in Victoria, and food safety testing.

Results indicate that FD-BBP is a viable, food-safe product with significant nutritional benefits, including high protein content (95.4g per 100g) and bioavailable iron (264 mg / 100 g)). While microbiological analysis showed some variability in results, the product generally met food safety standards. The project also assessed the regulatory classification of FD-BBP and found potential pathways for its use in both functional foods and nutraceuticals. The findings provide the Australian red meat industry with a sustainable alternative to traditional blood meal products and open new opportunities for FD-BBP in nutraceutical and functional food markets.

Executive summary

Background

This research addresses the underutilization of bovine blood products (BBP) in the Australian food industry. Bovine blood is rich in nutrients, particularly protein and bioavailable iron, making it an ideal candidate for use in functional foods and nutraceuticals. The study aimed to assess the technical feasibility and commercial viability of freeze-dried bovine blood as an ingredient for aging or iron-deficient populations, or for encapsulation in nutraceutical products. The project targeted meat processors, functional food manufacturers, and nutraceutical companies to understand the technical and food safety suitability of FD-BBP.

Objectives

The objectives of this project were:

- To **map out the proposed blood collection process** at the Tasmanian abattoir, ensuring compliance with industry standards and assess whether animal ethics approval was required.
- To establish a **licensing agreement** with The Local Meat Co. for blood collection.
- To collect the blood in a food safe way and evaluate the **feasibility and viability** of freezing and freeze-drying processes to produce FD-BBP.
- To **perform food safety testing**, including pathogen testing and quality assessment of the freeze-dried product.
- To conduct a **nutritional analysis** of FD-BBP to confirm its suitability as a functional ingredient.
- To carry out a **regulatory review** to determine the classification of FD-BBP under FSANZ (Food Standards Australia New Zealand) and TGA (Therapeutic Goods Administration) guidelines.
- To perform a **desktop assessment** of FD-BBP for its suitability in nutraceutical and functional food use.
- To deliver the **Final Report**, including commercial implications and a process diagram outlining the journey from abattoir to freeze-dried ingredient.

All objectives were achieved, except for the completion of a licensing agreement with The Local Meat Co. (Tasmania), although the project made significant progress in understanding the practicalities of blood collection at small-scale abattoirs.

Methodology

The methodology involved blood collection from cattle at a Tasmanian abattoir using standard industry procedures, followed by freezing and freeze-drying the blood at Forager Foods. The freeze-dried product underwent food safety testing at the University of Tasmania Microbiological tests

showed some variability in bacterial counts, so was repeated at a commercial laboratory along with nutritional testing.

A regulatory review was also conducted to assess the product's classification under FSANZ and TGA guidelines for functional food and nutraceutical use. Additionally, a consultant was engaged to conduct a desktop assessment of the potential applications of FD-BBP in functional foods and nutraceuticals. This research evaluated the feasibility of using FD-BBP in product formats such as a "Meal pudding" and gummy products, providing recommendations for further studies and market strategies.

Results/key findings

- **Feasibility of Blood Collection and Freeze-Drying**: The process was technically feasible, with the blood from one cow meeting food safety standards after freeze-drying.
- **Nutritional Content:** FD-BBP was found to be high in protein (95.4g/100g) and bioavailable iron (264 mg/ 100g).
- **Microbiological Safety:** one sample met food safety standards, and one sample showed unexpectedly high bacterial counts, suggesting the need for further investigation into contamination risks.
- **Regulatory Insights**: The study confirmed that FD-BBP could be classified as a food product under FSANZ guidelines, with some regulatory challenges for capsule formats.
- **Commercial Viability and Customer Interest:** The desktop research and consultant assessments provided examples for assessment of commercial interest for FD-BBP as a functional food and nutraceutical ingredient. Feedback from potential customers, such as Grassland Nutrition, showed interest in FD-BBP, particularly for its nutritional benefits as a high-protein and bioavailable iron source. While market adoption may face challenges due to consumer perceptions of blood-derived products, the findings suggest that innovative product formats such as gummies, puddings, and powders could help overcome these barriers and attract interest from the growing nutraceutical and functional food sectors.

Benefits to industry

- **Enhanced Utilization of Bovine By-products:** FD-BBP as food ingredients presents a valuable alternative to blood and bone meal, providing the red meat industry with potential for alternative revenue streams from co-products.
- **Functional Food Applications:** FD-BBP offers a potent source of bioavailable iron and high level of protein, ideal for functional foods and nutraceuticals targeting specific populations such as aging consumer or iron-deficient females.
- **Improved Sustainability:** The project aligns with sustainability goals by reducing food waste and utilizing an underused by-product.
- **Market Expansion Opportunities:** Initial interest from a small-scale Australian nutraceutical company highlights potential commercial viability.

Future research and recommendations

- **Optimization of Freeze-Drying Processes:** Further research to ensure consistent yields and minimize bacterial contamination.
- **Scaling Up Production:** Investigate the scalability of FD-BBP production at larger abattoirs.
- **Sensory Testing and Consumer Acceptance:** Explore techniques to address sensory challenges like metallic taste and dark colour to improve market acceptance.
- **Regulatory Pathways:** Further assessments on regulatory compliance for nutraceutical capsules and food formats.
- **Bioavailability Studies:** Conduct in vivo studies to confirm the bioavailability of iron and protein in FD-BBP.
- **Long-Term Stability Studies:** Explore shelf life and storage conditions for long-term product stability.

This research lays the foundation for expanding FD-BBP's use in the food industry, offering sustainable, high-nutrient alternatives for consumers and creating new market opportunities for the Australian red meat sector.

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1. Background

1.1 The opportunity: Bovine Blood Products (BBP) as functional food ingredients.

Bovine blood products represent a significant yet underutilized resource within the food industry in Australia. Rich in essential nutrients and functional bioactive compounds, BBPs offer numerous benefits that enhance the nutritional value, sensory properties, and functional characteristics of food products. It is also a cost-effective ingredient that has a positive impact on environmental sustainability (Ofori & Hseih 2012).

In 2024, 13,011,476 head of cattle were processed in Australia, according to MLA statistics on cattle production and slaughter. If all, this translates to over 200 million litres of bovine blood annually through cattle slaughter, based on an estimate of approximately 18 L of blood per head of cattle. Currently much of the BBP processed in the Australian red meat industry is processed into blood meal, a high-protein supplement for animal feed and an organic nitrogen fertilizer. The current price of blood meal per ton in 2025 is projected at AUD 1,184.67 (MLA Coproducts rendered 2025).

Despite being underutilized, especially in Australia, freeze-dried bovine blood is a versatile ingredient which could be used more across the food industry, especially for its nutritional richness and functional benefits. It serves as a high-protein and heme iron supplement in nutritional supplements available in the US and Australia, providing essential amino acids and iron e.g. a) Heart & Soil Life Blood b) SunPure Superfoods Beef Whole Blood, Spleen, Liver Capsules and (c) Vitazan Bovine Heme Iron.

A review article published in 2023 (Chiroque et al 2023) identified several uses for bovine blood:

- in meat products such as sausages and burgers, it acts as a binding agent and enhances colour, improving texture and overall quality.
- in bakery items, blood plasma proteins have been used as egg-replacers for improved sensory outcomes.

In general, bovine blood is not currently used in many food applications, as the presence of the heme moiety generally imparts an objectionable colour and flavour to the final product.

This project, funded under the High Value Food Frontiers program builds on previous MLA work investigating different value streams for BBP (Franks 2013, Glagovskaia *et al* 2013, Spooncer 2011) - this proof-of-concept study aims to investigate the feasibility and viability of freeze-dried bovine blood products (FD-BBP) as high protein, high heme iron ingredient/s for use in a functional food designed for aging, or low-iron populations, or for encapsulation into nutraceutical products and is a project run under the High Value Food Frontiers program.

Research outcomes sought to address the feasibility of an end-to-end process from collection at a small Tasmanian abattoir (The Local Meat Co), transportation, freezing then freeze drying at Forager Foods and then desktop assessment of the finished products with potential customers.

Two end use cases were assessed via a desktop assessment for technical feasibility and commercial viability:

- as an encapsulated ingredient in Meepo Meal Pudding™, a functional food high in protein and heme iron, designed by US startup Meepo Inc.
- as a powder for use in an encapsulated nutraceutical supplement supplied to one of Forager Foods current customers.

The main research question this proof-of-concept study sought to assess is:

Can a food-safe freeze-dried bovine blood ingredient be produced in a technically feasible and commercially viable way?

The audience for this research are meat processors, to understand the technical feasibility and commercial viability of the process), and functional food and nutraceutical companies to assess the technical and food safety suitability of the ingredient.

The results of this research will be used to highlight additional opportunities for bovine blood products as alternatives to lower value blood and bone meal.

2. Objectives

The objectives this research sought to address are:

1. Technical feasibility and commercial viability of FD-BBP as functional food and nutraceutical ingredient:
    a. Obtain Animal Ethics approval (if required).
    b. Map out proposed blood collection process.
2. Licensing agreement with The Local Meat Co.
3. Freezing and freeze-drying"
    a. The feasibility and viability of standard chilling then freezing prior to freeze drying
    b. Freeze drying of the products from the trial.
4. Food safety testing & nutritional analysis
    a. Pathogen testing and quality assessment
    b. Nutritional analysis
5. Regulatory review on FSANZ vs TGA classification for the final proposed products.
6. Desktop assessment of resulting FD-BBP for nutraceutical and functional food use.
7. Delivery of the Final Report including Commercial Implications such as:
    a. Preliminary observations for how this solution might comply with typical Australian Halal conditions for blood collection in an abattoir
    b. Process diagram of the process from abattoir to freeze-dried ingredient.
    c. Preliminary commercial viability and technical feasibility for a Tasmanian supply chain for FD-BBP.

All objectives were achieved, except for the completion of a licensing agreement with the Local Meat Co. Discussions with Sam Trethewey from the Local Meat Co. have highlighted that no new intellectual property has been created during this project, other than the production of the reports. Industry standard methods and equipment for blood collection were used, albeit modified to enable the trial to be conducted at a very small scale.

3. Methodology

3.1 Animal ethics approval

The project team consulted with a variety of ethics experts in Tasmania, at the University of Tasmania, State Government and independent consultants as well as food safety and animal welfare advisors to The Local Meat Co. to understand whether ethics approval was required.

As this case the blood collection for this project was collected using industry standard procedures (see 3.2 below) and no novel techniques were used. The animals were be stunned as per normal abattoir procedures prior to collection.

The blood collected for this project is coming from animals that are being slaughtered as part of the usual running of the abattoir, normally this blood would not be collected and would be a waste product.

3.2 Blood collection at abattoir

The blood collection process was mapped out for approval to determine whether ethics approval was required. The Local Meat Co abattoir in Tasmania used the standard manual sticking method, as described in MLA and AMPC Report A.BIO.0036 (Spooncer, 2011). Following stunning, sticking with a vampire knife into the jugular attached to a tube, flowing into a sterile stainless-steel container

Two British bred cattle (Cow A and Cow B) were randomly selected from the weekly kill for the project. Following stunning, sticking with a vampire knife (Image 1) into the jugular attached to a tube, blood flowed into two 20L stainless steel sterile containers (one for each cow) used to collect the blood. The blood was chilled and transported via a chilled transporter to Forager Foods Western Junction facility for freezing and subsequent freeze drying.

Image 1: Vampire knife used for collection	**Image 2: Stainless-steel collection vessel**
	

3.3 Freeze drying

The freshly collected blood from the two animals from The Local Meat Co abattoir arrived at the Forager Foods Western Junction site on Friday the 6th of December 2024 and was spread onto freeze dryer trays and stored in the blast freezer over the weekend. The samples were then dried using the freeze dryer on Monday the 9th of December 2024 at Forager Foods, and drying was completed on 10th December 2024.

The kill- step methodology is a proprietary and confidential trade secret to Forager Foods and is not included in the methodology for confidentiality reasons. Image 3 shows one of the large industrial freeze dryers at Forager Foods Western Junction facility, near Launceston Airport.

Image 3: Forager Foods Freeze dryer

3.4 Food safety testing & nutritional analysis

3.4.1 Food testing (pathogen testing) and quality assessment – University of Tasmania

Dr Jay Kocharunchitt, Senior Lecturer and Research Scientist in Food Microbiology, Centre for Food Safety and Innovation at the Tasmanian Institute of Agriculture was commissioned to evaluate the

food safety and quality of frozen and freeze-dried bovine blood products from a local processing plant. The primary objective was to assess the suitability of Forager Foods' freeze-drying capability and kill-step in producing a food-safe product.

Blood samples collected from two different animals (Cow A and Cow B) and subjected to freezing and freeze-drying processes. A total of two x 125 ml samples (fresh frozen, one from each cow) and 125 g of freeze-dried powder (one from each cow) were transported under cold chain transport conditions to the University of Tasmania's Microbiology Research laboratories for comprehensive microbiological analysis.

The study employed Australian Standard procedures to test for key bacterial indicators, including Total Plate Count (TPC), Coliforms, Escherichia coli, and Salmonella species. Both positive controls (i.e., a medium with a known organism) and negative controls (i.e. a medium without any sample) were also included in all tests to ensure the validity and reliability of the test results.

3.4.2 Food safety testing and nutritional analysis - Eurofins

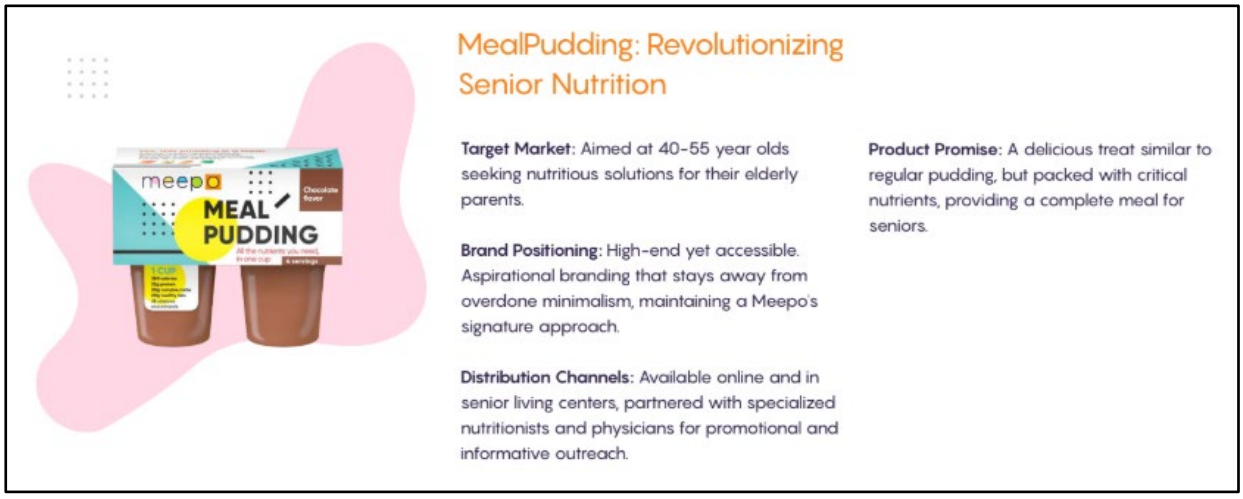
The samples of freeze-dried product were stored in sealed, foil bags flushed with nitrogen to ensure shelf stability. Sub-samples were sent to Eurofins Food testing laboratory in Melbourne for repeat testing of bacteria and pathogens for both freeze dried samples. Cow B (as had previously been shown to be food safe) was also tested for heavy metals and for information for the Nutritional panel. Appendix 1 shows the methods used for each sample.

3.5 Regulatory review on FSANZ vs TGA classification for the final proposed products.

KHQ Lawyers were requested to provide a regulatory review on the FSANZ vs TGA classification for two potential commercial products:

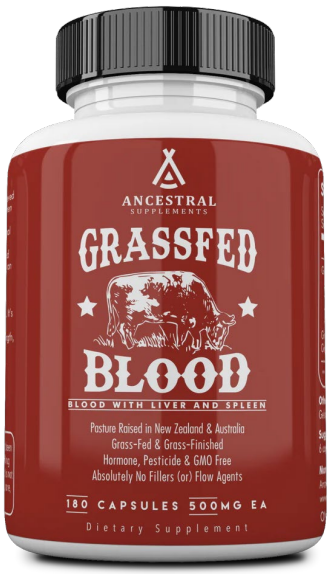
Product 1: A functional food product designed for aging consumers, such as the Meepo™ Meal Pudding product concept (shown in Image 5). KHQ were advised the blood powder would be encapsulated to reduce any metallic or unpleasant taste and that the meal pudding would contain a significant amount of hydrolysed collagen protein at amounts of 22g of protein per serve. It is expected the product would be chocolate flavoured to mask any brown colour.

Image 4: Senior Nutrition Meepo MealPudding™ Product Concept



Product 2: A nutraceutical capsule product such as one of the below commercially available examples shown in Table 1.

Table 1: Final Proposed products

Image 5: NXGen Whole Foods Grass-fed Whole blood.	**Image 6:** SUNPURE SUPERFOODS Primal Graze Iron	**Image 7:** Ancestral Supplements Grass-fed Blood
		
Ingredients declaration: Freeze-Dried 100% Australian Grassfed and finished whole blood (50%), Beef Liver (25%), Beef Spleen (25%), Gelatine Capsule.	**Ingredients declaration:** freeze-dried 100% Australian Grass Fed Whole Blood (50%), Organic Liver (25%), Organic Spleen (25%), Gelatine capsules.	**Ingredients declaration:** Grass fed, grass finished, New Zealand or Australian sourced bovine blood (33%, liver (33%), and spleen (33%), Gelatine capsules Blood is freeze-dried.
Country of Origin	**Country of Origin**	**Country of Origin**

statement/s: Made in Australia	**statement/s:** Product of Australia	**statement/s:** Manufactured in the US (Australian/NZ blood)
Price: $65 / 160 capsules 500 mg per capsule.	**Price:** $49.95 / 120 capsules 500 mg/capsule	**Price:** $82 / 180 capsules 500 mg / capsule
Recommended serving: 4 capsules 	**Recommended serving:** 4 capsules 	**Recommended serving:** 6 capsules 

3.6 Desktop assessment of resulting FD-BBP for nutraceutical and functional food use

3.6.1 Pudding format

The product from the trial was assessed for suitability as an ingredient in Meal Pudding™ by Meepo Inc (product concept shown in Image 1). Meepo Inc. is a startup that was identified from the scouting for the 2023 FoodTech Tasmania Accelerator. As of late 2024, Meepo Inc has pivoted into a new business called FitSweets and is no longer focussing on this senior nutrition area.

Meepo's former Chief Technical Officer was then engaged as a consultant to conduct a thorough analysis of how to effectively incorporate bovine blood into various edible formats, such as gummies and puddings. Eurofins test results of the products were provided.

The consultant was asked to assess the suitability of the OTH hydrolysed collagen for suitability in the product and to compare the resulting product concept to the Wicked Sister protein pudding (Image 2) as an example of a high protein product.

Image 5: Wicked Sister high-protein pudding

3.6.2 Nutritional supplement capsules format

Freeze-dried powdered product from the trial, was assessed for filling in a soft capsule form as a nutritional supplement by one of Forager Foods existing nutraceutical customers (Grassland Nutrition, https://grasslandnutrition.net/). A short questionnaire was provided to Owner Kel Sorenson to assess potential interest in the ingredient.

An example of the kind of product that could be made if this process was scaled is shown in Image 6 was sent to Grassland Nutrition as a product concept. Additional information found by Startupbootcamp's AI-enabled market research tools were also provided to the customer and are included in Appendix 2

Image 6: Nutraceutical example: Grassfed desiccated Beef blood supplement by Nutriest

3.7 Commercial Implications

3.7.1 Preliminary Implications for typical Australian Halal processing

To identify implications for halal processing, Startupbootcamp deployed a combination of desktop research with Startupbootcamp's AI Deep Research tools and verifying each individual reference provided to ensure no hallucination. This short summary was shared through an expert interview

with 2022/3 Startupbootcamp Entrepreneur-in-Residence Dr Syed Shahzad Shah who works as a technical auditor and food safety expert for a Halal Certification Body.

3.7.2 Process diagram of the process from abattoir to freeze-dried ingredient.

The process diagram was produced from combination of the mapped-out blood collection process, combined with process flow diagrams provided by Forager Foods.

4. Results

4.1 Animal ethics approval

Following consultant with experts as described in the methodology it was deemed that the experimental part of the project revolves around whether the freeze drying and "kill step" at Forager Foods can produce a food safe product. Because of this and the process being used for stunning and collecting blood is carried out at several abattoirs across the State (as is industry standard), it was deemed that the project does not require ethics approval

4.2 Blood Collection at the abattoir

Two 20 L stainless steel collection vessels (as shown in Image 2) were collected - one for each cow, the exact volume was not able to be measured. Subsamples of fresh blood were taken and stored in sterile plastic pots. The blood (both the bulk and sub-samples) was immediately chilled and transported to Forager Foods by chilled transport vehicle.

4.3 Freeze Drying

Prior to blast freezing and freeze drying the total amount of blood collected was weighed. Table 2 shows the weights of blood for each collection before and after freeze drying and the final moisture content.

Importantly no handling issues such as stickiness were observed. The product dried into a clumpy powder, as shown in Image 7.

Table 2: Weights of bovine blood samples pre- and post- freeze drying

Animal	Fresh blood weight	freeze-dried blood powder weight	Yield	% Moisture
Cow A	7.52 kg	1.45 kg	19.3 %	0.6 %
Cow B	6.00 kg	1.13 kg	18.0 %	0.5 %

Image 7: Freeze-dried bovine blood powder

4.4 Food safety testing & nutritional analysis

4.4.1 Food safety (pathogen testing) and quality assessment of the resulting freeze-dried products – University of Tasmania

The full results report is shown in the Appendix 3 and summarised in Table 3. Microbiological analysis revealed significant variations in bacterial counts across the samples. Both frozen bovine blood samples demonstrated consistently low total plate counts, ranging from 70 to 310 Colony Forming Units per gram (CFU/g). In contrast, the freeze-dried samples exhibited more variable results, with the Cow A sample showing a notably high TPC of 110,000 CFU/g, while the Cow B sample maintained a low count of 280 CFU/g.

Importantly, all samples showed negative or below-detection-limit results for coliforms, Escherichia coli, and Salmonella species. This indicates a generally high level of microbiological safety across the tested samples.

Table 3: Summary of the microbiological data for frozen and freeze-dried bovine blood products

Analysis	Frozen bovine blood		Freeze-dried bovine blood	
	Cow A	Cow B	Cow A	Cow B
Total plate count, TPC (CFU/g)	70	310	110,000	280
Coliforms (MPN/g)	<0.3	<0.3	<0.3	<0.3
Escherichia coli (MPN/g)	<0.3	<0.3	<0.3	<0.3
Salmonella spp. (/25 g)	ND*	ND	ND	ND

*ND = not detected

The unexpected high TPC in the freeze-dried Cow A sample required further investigation - both samples were dried in the same freeze dryer at the same time on clean trays. The variability suggests a need for further investigation as it is not expected for bacteria to grow during a drying process.

Forager Foods has suggested “there appears to have been some cross-contamination of the sample from Cow A at some point after drying”.

Except for the freeze-dried Cow A sample, all products met food grade standards. The analysis demonstrates the overall effectiveness of the processing methods, though some inconsistencies in the results require additional scrutiny and further testing. The project team recommended that the retained samples at Forager Foods be sent to a commercial laboratory for an additional set of food safety tests in case there was a contamination event at sub-sampling.

4.4.2 Food safety testing and nutritional analysis – Eurofins

Results from Eurofins microbial testing of samples included in Table 4. Table 5 includes a summary of relevant nutritional content such as protein and a selection of essential minerals or nutrients. Commentary has been added to compare the values in the blood against the recommended daily intake (RDI) for that particular mineral or nutrient as described in the Australian Government Eat for Health website (https://eatforhealth.gov.au). Of particular interest are the levels of both iron and copper as there is a link between iron deficiency and copper deficiency (Wazir & Ghobrial, 2017).

A complete set of results including Pivot tables are provided in Appendix 4a and 4b.

Table 4: Microbial Results (cfu/g unless otherwise stated)

Test	Cow A	Cow B
Salmonella (/25g)	Not Detected	Not Detected
Aerobic Plate Count	23,000	800
Bacillus cereus	<10	<10
Coliforms (35°C)	<10	<10
Moulds	220	30
Yeast	<10	<10

Table 5: Nutritional and Mineral of interest analysis - Cow B

Component	Result	Unit	Relevant RDI
Ash	3.9 ± 0.51	g/100 g	
Total Carbohydrates	0.00	g/100 g	

Energy (calculated)	395	kcal/100 g	
Energy (calculated)	1650	kJ/100 g	
Total Fat	0.8	g/100 g	
Moisture	1.45	g/100 g	
Protein (Nx6.25)	95.4	g/100 g	High protein ingredient
Iron (Fe)	264	mg/100 g	RDA for women 31-50 yr = 18mg /day RDI for women 51-70 yr = 8 mg / day
Sodium (Na)	1370	mg/100 g	would need to consider this in overall formulation
Copper (Cu)	0.54	mg/100 g	RDI for women 31-70 yr = 1.2 mg / day
Selenium (Se)	0.19	mg/kg	RDI for pregnancy of 65µg / day

4.5 Regulatory review on FSANZ vs TGA classification for the final proposed products

The detailed legal advice and assessment of the FSANZ and TGA regulatory classification for two proposed product formats provided by KHQ can be found in Appendix 5. The Executive Summary states the following points:

“Subject to our detailed advice below, KHQ advises that:

A. There are strong arguments that the key active ingredient – refined encapsulated bovine blood – should be classified as “food” and not as a “therapeutic good”.

B. However, many common encapsulation materials do not have approval for use in “food”. Further assessment of your encapsulation material is warranted.

C. While it is legally possible to sell a “food” product in capsule form, it is impossible to do so without some risk of the TGA taking action for sale of an unapproved therapeutic good.

D. One way to remove this risk but still provide a convenient, controlled dose product would be to use a traditional food format, such as powder sachets to be reconstituted into a beverage or a gummy.

E. Should you still choose to classify the product as “food” but still sell it in a capsule form, another way to mitigate risk of TGA action will be for any marketing claims to be very conservative and emphasising the food classification.

F. There may be compliant e-commerce/personal import pathways open to such a product, should they be manufactured outside of Australia.

G. The pudding format – due to only containing traditional food ingredients and being in a traditional food format – can choose to be either food or a therapeutic good. Even if classified as "food", this format has more flexibility and less risk in making more powerful marketing claims when compared to the capsule product.

H. Regardless as to which regulatory path is selected, we recommend that the manufacturing process of the key blood ingredient include controls that will guarantee a consistent nutritional profile as well as ensure product safety. This would include a kill-step such as used by Forager Foods.

4.6 Desktop assessment of resulting FD-BBP for nutraceutical and functional food use

4.6.1 Meal Pudding and Gummy format

The desktop assessment of the freeze-dried blood products is included in Appendix 6. The desktop assessment concludes that the FD-BBP is a viable nutraceutical ingredient with high potential for functional food applications. Being rich in bioavailable iron (264 mg / 100 g) and high-quality plasma proteins, it was deemed to be a suitable ingredient for use in formulation of a gummy product.

Mr Arrocha recommended that further studies are needed to confirm bioavailability. Despite sensory challenges such as metallic taste and dark colour, these could be dealt with by encapsulation strategies, hydrocolloid systems, and natural flavour and colour masking techniques to enable the ingredient to be integrated into innovative formats like gummies and puddings. A suggested recipe to trial the ingredient in a gummy format was also provided.

4.6.2 Nutritional supplement capsules format

Mr Kel Sorenson from Grassland Nutrition provided some feedback via email and a telephone call (see Appendix 2b) that the freeze-dried bovine blood product would be of interest to his business, both as a standalone product and as a potential blend along with other freeze-dried organs such as heart, kidney, liver or spleen.

The product was deemed suitable from a format standpoint. Mr Sorenson envisaged the product could be packaged the same way as his current products, either as a powder or included in a mixed product capsule.

Feedback provided on the product specifications whilst brief, seemed to indicate that the fine powdered format, flowability, hygroscopicity (4%) and colour met Grassland requirements. Mr Sorenson also expressed interest in the gummy recipe and assessment for a food product.

Grassland Nutrition currently manufactures three different format products: capsules, powders and chunks largely for the "Carnivore Market". Their range of products are sold as food products and labelled as such. Their organic beef products (which currently do not contain blood) are Halal certified by SICHMA.

"I have actually been thinking quite a bit of the possibilities for the blood, as a capsule product I am aware that it is already on the market, but are customers ready for blood? Our own capsule product "Iron Support" (Liver/Spleen) I thought would be a runaway product, because of the Iron, but only moving very slowly…" Kel Sorenson via email.

In a follow up telephone conversation Mr Sorenson expressed interest in a collaborative project with MLA focussing on appropriate marketing strategies for this type of product - as he had been surprised that their own Iron Support product was not performing as well as he had expected.

4.7 Commercial Implications

4.7.1 Preliminary Implications for typical Australian Halal processing

Desktop research supported by Startupbootcamp's AI Deep Research tool examined the compatibility of edible blood collection with halal-certified slaughter operations, focusing on regulatory, technical, and religious implications and is included in Appendix 7. We have included this report as an Appendix for ease of sharing externally.

Islamic law strictly prohibits the consumption of blood, and halal certification bodies globally do not permit blood-containing products to be labelled halal. However, viewing the available research we consider that sterile blood collection is technically feasible during halal slaughter if proper segregation and hygiene are maintained. New Zealand serves as a model, with over 90% of livestock slaughtered under halal protocols that incorporate reversible stunning and thoracic sticking, enabling efficient exsanguination and collection of 4.5–6 litres of blood per animal.

Although not used in halal food products, this blood is redirected to non-food applications such as pharmaceuticals. Key technical procedures—such as rapid collection within 30 seconds post-slaughter, sterilized equipment, and immediate chilling—ensure quality and regulatory compliance. These findings highlight that with strict management, halal slaughter and non-halal blood recovery can co-exist within the same facility without compromising halal integrity.

4.7.2 Process diagram of the process from abattoir to freeze-dried ingredient

The process flow diagram for the abattoir is shown in Image 8. The Halal slaughter best practice for this diagram is derived at from an old MLA report (Spooncer, 2012), which is more than 12 years old

The process flow diagram for freeze-drying is shown in Image 9.

Image 8: Recommended Halal suitable process for Blood Collection (in part from Spooncer, 2012)

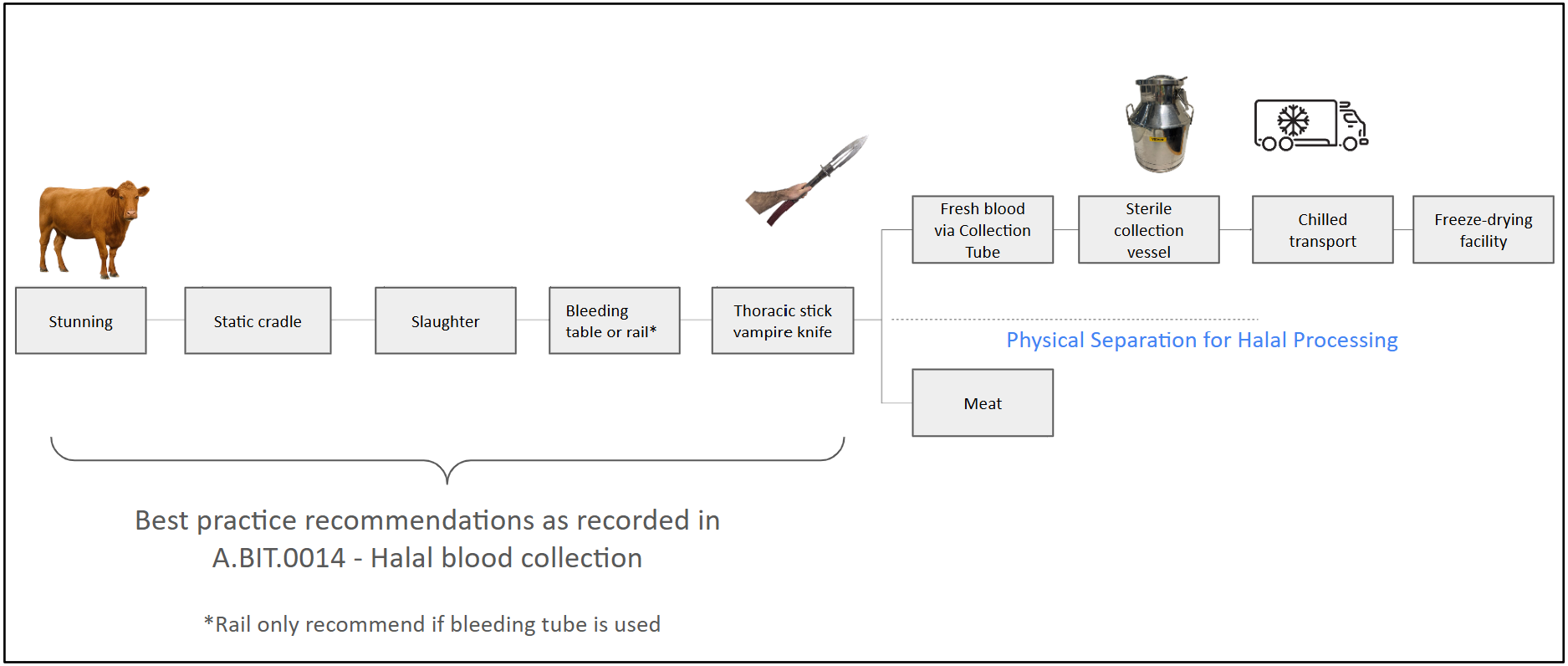
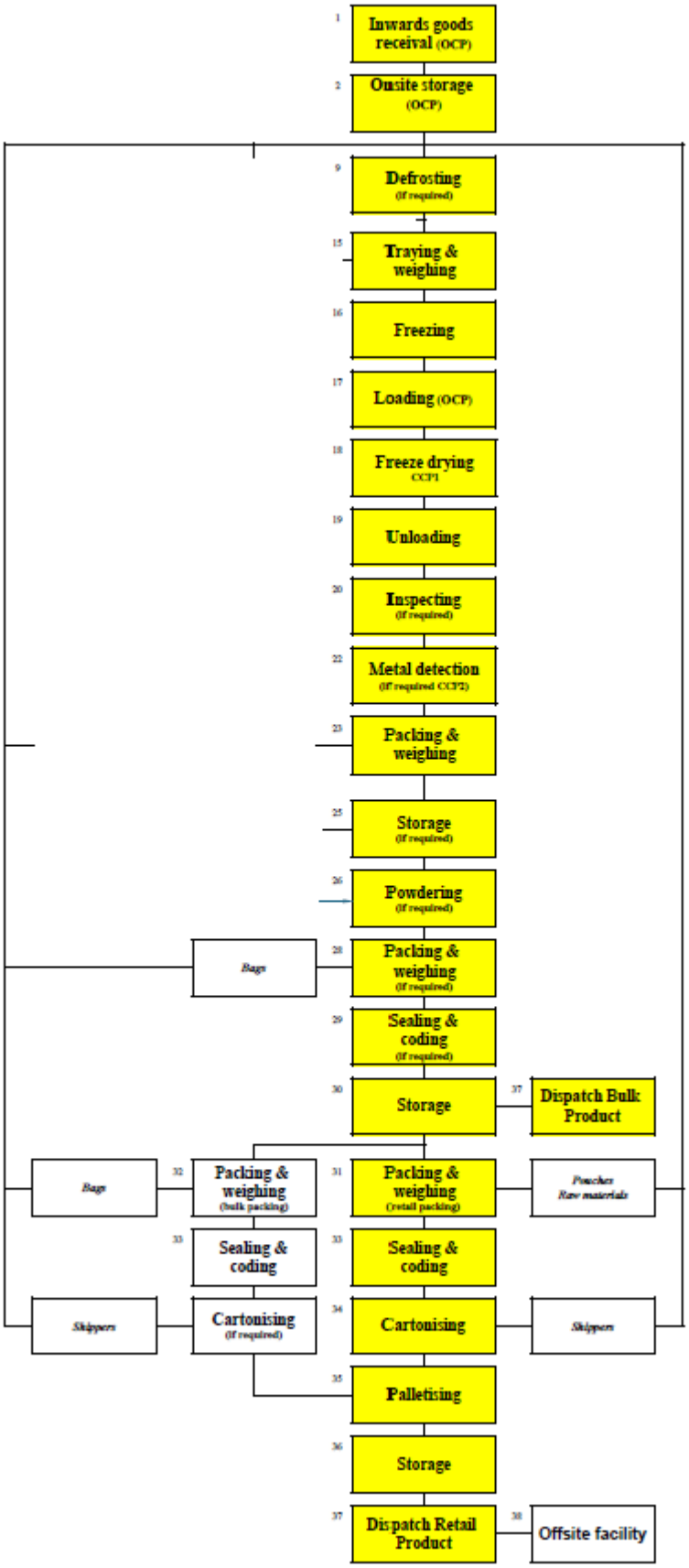


Image 9: Process flow diagram for freeze-drying (higher quality version is found in Appendix 8).



4.7.3 Preliminary commercial viability and technical feasibility for a Tasmanian supply chain for FD-BBP.

This project has highlighted that at a small-scale abattoir (processing approximately 20 head of cattle a week) it is technically feasible to collect and freeze dry bovine blood that is food safe.

Commercial viability is difficult to assess from such a small scale PoC, however indications of the yield of dried blood collected were greater than expected. Further comment on this is included in the conclusion.

5. Conclusion

5.1 Key findings

1. **Feasibility of Blood Collection and Freeze-Drying:** The project demonstrated that collecting bovine blood at a small-scale abattoir (processing 20 cattle per week) and subsequently freeze-drying it is technically feasible. The blood collected met food safety standards following a proper "kill-step" and freeze-drying process.

2. **Nutritional Composition:** The freeze-dried bovine blood (FD-BBP) is a high-protein ingredient, with 95.4g of protein per 100g, and contains significant amounts of bioavailable iron (264 mg / 100 g). This positions FD-BBP as a valuable ingredient for functional foods, particularly those targeting iron-deficient populations.

3. **Microbiological Safety:** The freeze-dried bovine blood for both animals met food safety standards at the freshly collected blood stage. After freeze drying one sample showed unexpectedly high bacterial counts. This indicates the need for further investigation into contamination points post-drying.

4. **Potential Commercial Viability:** While the small scale of this proof-of-concept study limits definitive conclusions about large-scale commercial viability, the trial yielded higher-than-expected yields of freeze-dried blood, which suggests potential for cost-effective production.

5. **Regulatory Considerations:** The regulatory review suggests that FD-BBP, when used as a functional food or nutraceutical, could be classified as food under FSANZ guidelines, though encapsulation materials need further assessment for compliance. Capsule formats may carry some regulatory risks, whereas traditional food formats (e.g., puddings, gummies) face fewer restrictions.

6. **Halal Considerations:** The assessment showed that while Halal processing standards prohibit blood in food, it is technically feasible to collect blood in a Halal-compliant manner with proper management of segregation and hygiene practices, without compromising the halal status of meat processed in the same facility.

7. **Market Interest:** Initial feedback from a potential customer, Grassland Nutrition, showed interest in FD-BBP as a nutraceutical ingredient. However, market adoption of blood-derived products may face challenges due to consumer perception.

5.2 Benefits to industry

1. **Increased Utilization of Bovine By-products:** This proof-of-concept study highlights an opportunity for the red meat industry to enhance the utilization of bovine blood, which is often discarded or underused. The findings provide a pathway for turning bovine blood into a high-value ingredient, thereby adding another revenue stream to the industry.

2. **Enhancing Functional Food Offerings:** FD-BBP can be used as a potent source of bioavailable iron and protein, offering functional food manufacturers a unique ingredient that could cater to aging populations or those with iron deficiencies. This could particularly benefit companies in the growing functional foods and nutraceutical sectors. Additionally, utilizing FD-BBP as a high heme-iron and high protein ingredient provides alternative to less easily tolerated pharmaceutical solutions.

3. **Food Safety and Quality Standards:** The successful demonstration of food-safe FD-BBP opens doors for further innovations in blood-based food ingredients. By ensuring quality and safety through rigorous testing, the industry can establish a standardized process for incorporating FD-BBP into various food products.

4. **Expansion of Halal Product Offerings:** Although Halal certification remains a complex issue for blood products, this project's exploration of blood collection methods that minimise implications for Halal certified meat processors may enable the development of a new market opportunities for blood products

5. **Environmental and Cost Efficiency:** The ability to repurpose bovine blood, a typically wasted by-product, aligns with sustainability goals by reducing food waste and improving the environmental footprint of meat processing.

6. **Collaborative Opportunities and Market Expansion:** With potential interest from a small Australian nutraceutical company, this research could foster new industry collaborations and encourage market expansion into sectors such as health supplements, functional beverages, and more. The proof-of-concept study provides some incentive for future MLA investment towards scaling of FD-BBP production, benefiting both small-scale processors and large food manufacturers.

6. Future research and recommendations

1. **Optimization of Freeze-Drying Process:**
   Objective: Further investigation is needed into the freeze-drying process to enhance yield consistency and reduce variability in microbiological results, particularly for samples like Cow A, which exhibited unexpectedly high bacterial counts.
   Recommendation: Research should focus on refining the freeze-drying and post-drying handling processes to identify and mitigate contamination sources and incorporate recommendations into the facility's quality assurance system.

2. **Scaling Up Production:**
   Objective: This proof-of-concept study was conducted on a small-scale abattoir with only 2 animals. Scaling up the production of FD-BBP is essential to assess commercial viability.
   Recommendation: Future studies should focus on evaluating the commercial scalability of the production process, including the feasibility of sourcing bovine blood from larger abattoirs, ensuring food safety, and maintaining consistent quality in large batches.

3. **Market Sensory and Consumer Perception Studies:**
   Objective: Despite the nutritional benefits, there may be resistance to blood-derived food products, particularly due to sensory properties like metallic taste and dark colour.
   Recommendation: commission a food science team to build the gummy prototype and pudding prototype (this could be competed at FaBA). Conduct sensory testing and consumer preference studies to assess how to mitigate sensory challenges using encapsulation, flavour masking techniques, and product formulation (e.g., blending with other ingredients). Understanding consumer acceptance is crucial to the widespread adoption of FD-BBP-based products.

4. **Regulatory Pathways for Nutraceutical Capsules:**
   Objective: The project identified potential regulatory challenges for FD-BBP in capsule form, particularly regarding classification as a food or therapeutic good.
   Recommendation: Any products made for market testing (as per the recommendation (3) above, should be checked by a regulatory professional for appropriate classification (FSANZ or TGA) to confirm the regulatory landscape for blood-derived products in different formats.

5. **Bioavailability Studies:**
   Objective: While FD-BBP was identified as a source of bioavailable iron, further studies are required to confirm the bioavailability of essential nutrients, particularly for populations with specific needs (e.g., aging or iron-deficient populations).
   Recommendation: Conduct in vivo studies to confirm the absorption rates and effectiveness of FD-BBP as a source of bioavailable iron and protein. This would strengthen the case for its inclusion in functional foods designed to address nutritional deficiencies.

6. **Long-Term Stability and Shelf-Life Studies:**
   Objective: The freeze-dried bovine blood product demonstrated promising stability during the trial, but further studies are necessary to assess the shelf life and long-term storage conditions.
   Recommendation: Conduct accelerated shelf-life studies to determine the stability of FD-BBP in different product formats (e.g., powder, capsules, gummies). This will help optimize storage conditions, minimize degradation of bioactive components, and ensure product safety over extended periods.

7. **Market Expansion and New Product Development:**
   Objective: FD-BBP shows potential as an ingredient for functional foods and nutraceuticals. However, future research could investigate other potential product formats and market segments.
   Recommendation: Research should explore novel product development opportunities, such as functional beverages, protein bars, or other snack formats that incorporate FD-BBP. Targeted market studies could also help identify emerging trends in the health and wellness sector that align with the benefits of FD-BBP.

7. References

Renato Gustavo Silva Chiroque, Heber P. Cornelio-Santiago, Luis Alfredo Espinoza-Espinoza, Luz Arelis Moreno-Quispe, Lucia R. Pantoja-Tirado, Lilia M. Nieva-Villegas, and Mayda A. Nieva-Villegas **(2023).** *A Review of Slaughterhouse Blood and its Compounds, Processing and Application in the Formulation of Novel Non-Meat Products*, *Current Research in Nutrition and Food Science*, Vol. 11, No. (2), pp. 534-548. Enviro Research Publishers. Available from: http://dx.doi.org/10.12944/CRNFSJ.11.2.06

Philip Franks, Utilisation of blood and blood components in pet foods Mars Petcare Australia MLA Project P.PSH.0415. Final Report October 2013 https://www.mla.com.au/contentassets/f590e20c8d5e43df8146c281537dba0b/p.psh.0415_final_report.pdf

Olga Glagovskaia, Kirthi DeSilva, Regine Stockmann (2013) CSIRO Animal, Food and Health Sciences Date MLA & AMPC Project A.BIT.00200 Final Report February https://www.mla.com.au/contentassets/e0e255db21b64b98aee1c005db556c0f/a.bit.0020_final_report.pdf

Jack Appiah Ofori and **Yun-Hwa Peggy Hsieh (2012).** The Use of Blood and Derived Products as Food Additives, Food Additive, Prof. Yehia El-Samragy (Ed.), ISBN: 978-953-51-0067-6, InTech, Available from: http://www.intechopen.com/books/food-additive/the-use-of-blood-and-derived-products-as-food-additives

Meat & Livestock Australia (MLA) (2024). *Co-products Rendered – Prices & Markets Statistics*, Meat & Livestock Australia. Available from: https://www.mla.com.au/prices-markets/statistics/coproducts-rendered/ [Accessed 17 February 2025]

Bill Spooncer (2011), Kurrajong Meat Technology Pty Limited, MLA and AMPC Report: A.BIO.0036 Blood processing capability analysis. Final Report June 2011

Bill Spooncer (2012), Kurrajong Meat Technology Pty Limited, MLA and AMPC Report A.BIT.0014 - Halal blood collection. Final report February 2012

Sorenson, K (2025) personal communication (pers.comms 17 April 2025), Grassland Nutrition, Co-Founder and CEO

Shahzad Shah, Dr. S (2025) personal communications (pers. comms 23 March 2025) Technical Auditor/Expert, R & D Scientist and Consultant, PhD in Food Microbiology, Centre for Food Safety and Innovation, University of Tasmania, Australia

Arrocha, A (2025) personal communications (pers. comms 18 April 2025) Meepo Inc. Chief Technology Officer.

Wazir, S. M., & Ghobrial, I. (2017). Copper deficiency, a new triad: anemia, leucopenia, and myeloneuropathy. *Journal of Community Hospital Internal Medicine Perspectives*, *7*(4), 265–268. https://doi.org/10.1080/20009666.2017.1351289.

8. Appendix

8.1 Eurofins testing methodology for food safety, heavy metal and nutrition analysis

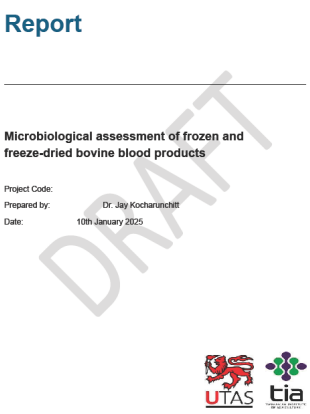
Test	Cow A	Cow B	Method Used
Appearance - Colour	✓	✓	NV0DQ - Internal Method (CM-010)
Salmonella (/25 g)	✓	✓	ZMKY0 - AOAC-RI 121501
Aerobic Plate Count (30°C)	✓	✓	ZML6W - PCA Agar-P: AS 5013.5
Bacillus cereus	✓	✓	ZML77 - MYP Agar-S: AS 5013.2
Coliforms (35°C)	✓	✓	ZMKVI - AOAC 991.14
Moulds	✓	✓	ZMM4T - AOAC 997.02
Yeast	✓	✓	ZMM4T - AOAC 997.02
Ash		✓	NV02S - Internal Method (CM-052)
Total carbohydrates		✓	NV078 - Internal Method (CM-058)
Energy (kcal & kJ)		✓	NV079 - Internal Method (CM-058)
Total fat		✓	NV095 - ISO 11085
Moisture		✓	NV0GA - Internal Method (CM-044)
Protein (Nx6.25)		✓	NV098 - AOAC 2001.11
Calcium (Ca)		✓	NU676 - AOAC 2011.14 mod. (Microwave)
Iron (Fe)		✓	NU610 - AOAC 984.27 mod. Hotblock
Magnesium (Mg)		✓	NU684 - AOAC 984.27 mod. Hotblock
Phosphorus		✓	NU692 - AOAC 984.27 mod. Hotblock
Potassium (K)		✓	NU680 - AOAC 984.27 mod. Hotblock
Sodium (Na)		✓	NU688 - AOAC 984.27 mod. Hotblock
Zinc (Zn)		✓	NU616 - AOAC 984.27 mod. Hotblock
Copper (Cu)		✓	NU613 - AOAC 984.27 mod. Hotblock
Manganese (Mn)		✓	NU619 - AOAC 984.27 mod. Hotblock
Aluminium		✓	NW899 - Internal Method
Antimony (Sb)		✓	NW877 - Internal Method
Arsenic (As)		✓	NW878 - Internal Method
Cadmium (Cd)		✓	NW879 - Internal Method

Chromium (Cr)		✓	NW881 - Internal Method
Lead (Pb)		✓	NW886 - Internal Method
Mercury (Hg)		✓	NW889 - Internal Method
Nickel (Ni)		✓	NW890 - Internal Method
Selenium (Se)		✓	NW892 - Internal Method
Silver (Ag)		✓	NW893 - Internal Method
Thallium (Tl)		✓	NW896 - Internal Method
Tin (Sn)		✓	NW895 - Internal Method

8.2 Appendix 2: Freeze Dried bovine Blood market products

Appendix 8_2_
Freeze-Dried Bovine

8.3 Appendix 3: University of Tasmania report


Report

Microbiological assessment of frozen and freeze-dried bovine blood products

Project Code:
Prepared by: Dr. Jay Kocharunchitt
Date: 10th January 2025

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8.4 Appendix 4: University of Tasmania report

Appendix 8_4
Eurofins test results /

8.5 Appendix 5: KHQ Letter of Advice

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MELBOURNE VIC 3000
PO Box 397
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Our Ref: CF.MC.20051

16 January 2025

Attn: Anna Barlow
ACH Australia Pty Ltd t/as Startupbootcamp
Level 17, 31 Queen Street
MELBOURNE VIC 3000

By email: anna@startupbootcamp.com.au

Dear Anna,

Regulatory classification of encapsulated bovine organ products

You have instructed KHQ Lawyers to advise Startupbootcamp with its project for Meat & Livestock Australia by providing legal advice and assessment of the FSANZ and TGA regulatory classification for two proposed product formats which contain refined, encapsulated bovine blood as a key ingredient.

Executive Summary

Subject to our detailed advice below, KHQ advises that:

A. There are strong arguments that the key active ingredient – refined encapsulated bovine blood – should be classified as "food" and not as a "therapeutic good".

B. However, many common encapsulation materials do not have approval for use in "food". Further assessment of your encapsulation material is warranted.

C. While it is legally possible to sell a "food" product in capsule form, it is impossible to do so without some risk of the TGA taking action for sale of an unapproved therapeutic good.

D. One way to remove this risk but still provide a convenient, controlled dose product would be to use a traditional food format, such as powder sachets to be reconstituted into a beverage or a gummy.

E. Should you still choose to classify the product as "food" but still sell it in a capsule form, another way to mitigate risk of TGA action will be for any marketing claims to be very conservative and emphasising the food classification.

F. There may be compliant e-commerce/personal import pathways open to such a product, should they be manufactured outside of Australia.

G. The pudding format – due to only containing traditional food ingredients and being in a traditional food format – can choose to be either food or a therapeutic good. Even if classified as "food", this format has more flexibility and less risk in making more powerful marketing claims when compared to the capsule product.

H. Regardless as to which regulatory path is selected, we recommend that the manufacturing process of the key blood ingredient include controls that will guarantee a consistent nutritional profile as well as ensure product safety.

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8.6 Desktop Assessment of FD-BBP

Appendix 8_6
Feasibility Report Gu

8.7 Implications for Halal Certified abattoirs

Appendix 8_7_
Halal-Certified Abatt

8.8 Process Flow diagram for Freeze drying

Appendix 8_8 Flow
diagram Beef Blood I