final report

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Prepared by: Darren Harpur

Aduro Biopolymers Limited Partnership

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Meat and Livestock Australia Limited

Locked Bag 991

NORTH SYDNEY NSW 2059

Novatein biopolymer

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Executive Summary

This project set out to develop a minimum viable product from a new and novel bioplastic made from bloodmeal with the objective of creating better value for bloodmeal produced by the Australian red meat industry. The product selection techniques and methods discussed in this report could have selected a product to solve a problem in an industry not related to meat processing. This would have meant the sole benefit out of the project for the red meat industry would be the conversion of bloodmeal into Novatein® resin. What this project has delivered is a bioplastic material with the potential to solve many of the plastic contamination issues faced not only by Australian meat processors, but those around the globe.

The Port Jackson lamb rectal plug made from Novatein® was developed in partnership with Sydney based Bestaxx Innovation who own the Port Jackson design rights. The Port Jackson specifically addresses the strong desire out of the red meat industry for plastic products that are renderable and non-detectable in downstream rendered meals and tallows at a price point that makes a strong case for adoption by the industry.

Over 10,000 Port Jackson's were manufactured by Aduro using Novatein® IR3020 and trialled in lamb processors in New Zealand and Australia. Less than 2.0% of the Port Jackson plugs failed to remain in the carcass through to the bung drop station compared to 5% to 15% failure rate of the plugs normally used. All processors trialling the Port Jackson indicated a strong willingness to look at using the plug when it becomes available. Trials of the Port Jackson in bobby calves received mixed results. The geometry of the plug made insertion difficult in the smaller orifice of the bobby calf compared to ovine.

In October 2014 a new Cost Benefit Analysis was completed by Gareth Forde (ex Lycopodium, now self-employed). This most recent cost benefit analysis published under project code P.PSH.0632 summarizes the findings for a project to manufacture Novatein™ in Australia at an undefined location.

Table 1 is extracted from that CBA

TABLE 1 SUMMARY OF COST BENEFIT ANALYS COMPLETED OCTOBER 2014

Metric	***Novatein® Manufacturing Scenario***	
	1000 tpa	*Ramp up over 4 years to 1000 tpa*
Main plant and equipment cost	*$366,727*	*$366,727*
Total capital investment	*$1,000,629*	*$1,000,629*
Discounted payback period	*0.9 years*	*4.4 years*
Simple present value $/head	*$3.04 / head*	*$2.49 / head*
Net present value $/head	*$2.18 / head*	*$1.56 / head*
Net present value	*$8,735,113*	*$3,982,977*

Several presentations on this project have been made to the Australian red meat industry including March 2015 where Aduro was invited to attend an MLA workshop (V.COP.0077-2015 Co Products Adoption Industry Workshop). To date whilst there has been strong interest from the red meat industry in products made from Novatein® it has not been matched with a desire to invest in a Novatein® resin production facility. Much of this can be put down to a reluctance to invest in anything that is not core business and processing bloodmeal into a plastic is not being seen as core business to bovine and ovine processors.

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1 Background

1.1 Aduro Biopolymers Limited Partnership

Project P.PSH.0632 was entered into by Novatein Limited, a New Zealand based business that was acquired by Aduro Biopolymers (also New Zealand based) as a result of investment negotiations between Novatein Limited's shareholders and Wallace Corporation Limited. Wallace Corporation is one of New Zealands largest rendering companies and a producer of bloodmeal. This project was transferred to Aduro Biopolymers as the new owner of Novatein Limited's intellectual property and assets.

Aduro Biopolymers is a pre-revenue research and development company commercialising Novatein®, a bioplastic capable of being injection moulded into a range of products. Whilst many production opportunities have been identified, project P.PSH.0632 was designed to select and develop a product to consume Australian bloodmeal through the location of a Novatein® resin production facility in Australia following soon after the completion of the project.

1.2 Novatein

Prior to commencing P.PSH.0632, MLA conducted an ex-anti CBA under contract A.BIM.0037, that validated the business opportunity and Novatein's® technical performance. Trials conducted by CSIRO have validated the resin has similar properties to LDPE and cost estimates have indicated that Novatein® resin can be manufactured at a price competitive with LDPE ($2100 per ton in the CBA for Novatein resin compared to listed LDPE market prices of $1765 to $2538/t with a 15% margin on biodegradable LDPE taking these prices to $2030-$2920).

The reported noted that this bioplastic could provide a significant new market for bloodmeal and an new opportunity for meat processors to gain, not only from increased demand for this low value co-product, but also from manufacture of resin from bloodmeal which provides a significant and practical value-add opportunity.

MLA commissioned a CBA under contract A.BIM.0037 through Lycopodium Process Industries PTY Ltd which showed a discounted payback period of 0.81 years and NPV of $2.51 / head based on a total capital investment of $2.0m. The CBA identified many opportunities (running process closer to capacity, using second hand equipment, and using wet as opposed to fully dried bloodmeal) to make the business case even more attractive.

The global LPDE demand was estimated to be 17.76m tonnes in 2009 and growth is predicted to be up to 9% year on year through to 2025. Global biopolymer demand was estimated at 258m tonnes in 2010. In a June 2012 meeting between Aduro and Ken Briggs, Application Development Manager of BASF in Melbourne, Ken stated the Australian bioplastics market is expected to reach 2.0m tonnes by 2017. To put this into context BASF, one of the larger bioplastic producers currently manufacture 75,000 tonnes of bioplastic each year.

Before P.PSH.0632 began, JBS and Nippon Ham indicated “in-principle” support for the technology and thought it provided not only a new value adding opportunity but would assist in management of their waste stream. Both processors suggested drying blood to 15%

rather than 7% required for bloodmeal. The aforementioned CBA included this scenario in its analysis and modelled a DPP of 0.80 years and simple present value per head of $3.60

Aduro Biopolymers entered into P.PSH.0632 with the intention of selecting and developing a product opportunity best suited to the properties of Novatein resin to create the most value for bloodmeal suppliers and the Australian red meat industry.

2 Projective Objectives

Project P.PSH.0632 set out to achieve the following objectives.

2.1 Selecting a Lead-In Product

Many products can be made from Novatein® and have been identified by Aduro prior to the commencement of this project. The outcome of this objective was to build on those possibilities, and to follow the value and supply chain through to the end-user to ensure the product can be supplied the desire price point. This requires in depth consultation with Australian based product designers, product manufacturers, distributors and end-users. Matching Novatein's® properties to the properties required by the selected product was also an important factor in this objective.

2.2 Optimising a Novatein® formulation

Having selected a lead-in product(s), this objectives sought to develop and optimise a Novatein® formulation to match the physical and mechanical properties of the product. The choice of lead-in product would be critical to the outcome of this objective.

2.3 Product manufacturing trials

Various Novatein® formulations would be injection moulded in a prototype mould built to assess Novatein's® behaviour when processed into the chosen product, and more importantly whether the product had the desired mechanical and physical properties.

2.4 Product trials

This objective set out to have end-users trial the product to assess its effectiveness and whether it would meet the expectations and performance criteria identified.

2.5 Demonstration to the Red Meat Industry.

MLA, Aduro and Gareth Forde from Lycopodium will present the business case for production of Novatein® biopolymer to the red meat industry and plastic production companies. This will include the results of resin trials and ex-ante cost benefit analysis.

3 Methodology

3.1 Product Selection

3.1.1 Eliminating the Impossible

The first phase of product selection began with eliminating manufacturing processes that were clearly inappropriate for Novatein® based on knowledge and experience held by Aduro at the time the project began. Manufacturing by filming, blow molding, vacuum forming, sheet-extrusion were eliminated, implying products made by these methods were automatically excluded. This left products made from injection moulding the primary focus.

Product groups were eliminated where longevity or strong mechanical properties were required over a long period of time while shorter life product groups were included if mechanical properties were less critical.

The purpose of this assessment strategy was to eliminate products, such as ear tags, where environmental conditions and product life-span could not yet be provided by Novatein®. However, given the large range of plastic products, identifying what could not be done made it easier to know what could.

3.1.2 Matching Novatein® properties to product requirements

Novatein® has a unique set of physical and mechanical properties that can be manipulated to a certain degree. For example, like all bioplastics, it will absorb or loose moisture to the environment which changes its base properties. Changes to the type or blend of additives used to make Novatein® can alter this characteristic. Stiffness or brittleness, impact and tensile strength can all be altered by using different ratios of additives.

Knowing Novatein's® "base performance" and how it could be manipulated, combined with the work that could be done within the scope of this project, further eliminated certain product groups and opportunities.

3.1.3 Value and Supply Chain Assessment

For this project to be successful this work had to be carried out in Australia. Interviews were held with plastic manufacturers and end-users of products to identify where Novatein™ might be used to solve a niche industry problem. This included many phone calls and several visits from NZ to Australia to discover areas of potential opportunity.

3.1.4 Partnering

Aduro's desire was to partner with a product design company or injection moulding company in Australia who could assist Aduro in the symbiotic design of product, tooling (for injection molding) and Novatein® formulation that was seen as critical to the outcome of this project. With a view of setting up a Novatein® resin manufacturing process in Australia, following the conclusion of this project, a lot of work was completed in understanding the Australian plastics industry from suppliers of resins to product converters, distributors, retailers and end-users.

3.2 Optimising a Novatein™ Formulation

3.2.1 Knowing the Boundaries.

Before a product was selected, a significant amount of work was completed to create a range of Novatein® blends that broadened the range of technical and physical properties of Novatein®. Over 300 batches of Novatein® were made and tested with data logged in a spreadsheet. This information was used to inform what might be possible when looking at possible product opportunities, and combined with the time frames within this project Aduro was able to include and eliminate opportunities.

3.2.2 Incremental Optimisation.

Once a product was selected and its specification profile was well understood, the base formulation for Novatein® was optimised over a series of production runs. Modifications to the ratio and blend of additives and processing conditions were made in logical well considered stages. Test bars of Novatein® for each stage of the re-worked Novatein® formulation were produced and submitted for testing and assessed against the benchmark specification profile of the chosen product.

During this optimisation phase it was important to keep in mind the key objective of producing a formulation that would allow for economic production of the part. Whilst expensive additives could be used to address or correct certain properties this might mean the resulting Novatein® formulation would be too expensive making the part too expensive for sale to the end-user.

3.3 Product Manufacturing Trials.

Assuming that injection moulding would be the preferred manufacturing technique a prototype mold would be built to run short production runs of the product. This would both serve to prove that any chosen Novatein® formulation could be processed in an injection molding machine and into the product mold, both of which are not a given or automatically assumed fact. The critical aspects to be confirmed here were that Novatein® can be processed in a manner that would not be an impediment to commercial scale production of the part, that the part produced met the desired specification profile, and finally that the part would perform as required in the hands of the end-user.

4 Results

4.1 Product Selection

4.1.1 The Problem of Plastic Contamination in Rendered Products

It is well known within the red meat industry that plastic clips and bungs used in the processing of animals can contaminate rendering feedstocks resulting in plastic pollution of tallows and meals. Bestaxx Innovation is a Sydney based company designing and distributing products targeted at the Australian red meat sector. The Bumdum™ developed by Bestaxx and presently on the market, seals the rectum of small stock from the point of application through to evisceration. The Bestaxx plug is made to be clearly visible on the viscera table attached to the large intestine and creates an additional process monitoring inspection point for processors. The product is manufactured from high performance polypropylene. Products like the BumDum ™ and those produced by companies such as Adept Plastics in New Zealand (who produce over 110 million clips and bungs for the international ovine and bovine market) are generally not removed from the animal's large intestine (standard operating procedure), and eventually make its way into the rendering process.

Novatein's® biodegradation properties and manufactured price point are specifically relevant to solving the problem of plastic residues in rendered co-products.

4.1.2 The Port Jackson Lamb Rectal Plug

Aduro partnered with Bestaxx Innovation to design a new lamb rectal plug that would better the products currently on the market on price and performance. The Port Jackson was designed to be sympathetic to the properties of Novatein® resin whilst overcoming the shortfalls of current bungs used in small stock. The short lifespan and requirement to degrade quickly in the rendering process nicely matches Novatein's® intrinsic properties to that of the Port Jackson.

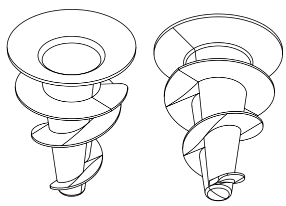

Fig 1 The Port Jackson lamb rectal plug

4.1.3 Optimising a Novatein® Formulation

Plugs on the market are generally made from a foam sponge, cardboard, high impact strength polypropylene or polyvinyl alcohol (PVOH) polymers, a recent development by Adept Plastics in New Zealand.

A broad scoping study allowed selection of a targeted approach for this objective; these were reducing the water content in Novatein® as well as improving strength and toughness using fibres or rubber additives. Some other plasticization options were also evaluated. The ultimate aim was to develop a Novatein® resin that closely matched the properties of polypropylene BE961MO currently used by Bestaxx to manufacture sheep bungs. Of these, the primary aims were to achieve:

- Shrinkage ≤ 2%
- Tensile strength 20-23 MPa
- Impact strength as close as possible to 14 KJ/m^2 at 20°C

Three base formulations, in addition to the original Novatein® formulation (crude pre-2013) for first round injection moulding trials were selected, along with minor modifications that may improve on these formulations (Table 1). All three base formulations were blends with the highest and most promising potential. CRUDE* is based on CRUDE PRE 2013, but with processing water reduced to promote stiffness during moulding and reduce shrinkage. Its mechanical properties are below that desired for the part in development, but it will still be included in moulding trials as a reference for moulding behaviour.

FIBRE is based on CRUDE PRE 2013 with the addition of a specific grade of purified cellulose fibre. This was the only additive screened during first round resin optimisation that had both a sizeable positive improvement in tensile strength (~50%) and modulus, along with an improvement in impact strength. Optimisation of fibre dispersion and interfacial adhesion may improve properties further.

STIFF is a reduced additive formulation, with the same moisture content as CRUDE* but omitting urea and reducing SS and SDS. Although more brittle, this blend has low shrinkage compared with early brittle blends, exceeds the conditioned stiffness target and with small amounts of TiO_2 added exceeds the strength target identified in first round resin optimisation. It is also stiff enough during moulding for self-ejection from the current ASTM dogbone mould. Going forward, this blend will be the base blend for rubber toughening efforts. The omission of urea may help with the interaction between protein chains and functionalised additives with maleic groups.

Table 2: Properties of selected base formulation.

	CRUDE-PRE 2013	***CRUDE****	***FIBRE***	***STIFF***
Bloodmeal	*100*	*100*	*100*	*100*
urea	*10*	*10*	*10*	*0*
SS	*3*	*3*	*3*	*1*
SDS	*3*	*3*	*3*	*1*
TEG	*20*	*20*	*20*	*20*
Fibres	*0*	*0*	*20*	*0*
water	*40*	*25*	*40*	*25*
Tensile strength (MPa)	*8*	*8.5*	*11.9*	*18.3*
Tensile modulus (GPa)	*0.4*	*0.5*	*0.9*	*1.6*
Strain at break (%)	*30-50%*	*20%*	*6%*	*2%*
Notched Charpy impact strength at 23 °C (kJ/m^2)	*0.8-1.4*	*0.6*	*1.6*	*0.6*
Longitudinal Shrinkage of dogbone during conditioning				*3-4%*

Following further optimisation trials Novatein® IR3020 was developed and is the formulation selected for manufacture of the Port Jackson.Table 2 shows the changes in properties between, our base formulations and IR3020 the formulation to be used to manufacture the Port Jackson.

TABLE 3: PROPERTIES

	Novatein® Crude		***Novatein® IR3020***	
Composition of granules				
Renewable base biopolymer	*57%*		*65%*	
Moisture content	*23%*		*19%*	
Other additives	*20%*		*16%*	
Renewable content (dry basis)	*77%*		*81%*	
Recommended injection molding temperatures	*100°C (feed zone) 120°C (die) 30-50°C (mold coolant)*		*100-200°C (feed zone) 150-170°C (die) 50-60°C (mold coolant)*	
Properties of moulded parts	*As moulded*	*Conditioned **	*As moulded*	*Conditioned **
Moisture content	*23%*	*10%*	*17%*	*10%*
Glass transition temperature	*18°C*	*65°C*	*Not measured*	*80°C*
Young's modulus (MPa)	*20-50*	*350-400*	*200*	*1500*
Ultimate Tensile Strength (MPa)	*1.8*	*6-8*	*3.5*	*18-20*
Tensile strain at break	*23%*	*35-50%*	*25-30%*	*2%*
Impact strength (kJ/m²	*Not measured*	*1.4*	*2.5*	*1*

**** Moulded test pieces conditioned for 7 days at 23°C and 50% relative humidity***

4.2 Product Manufacturing & Product Trials

Over 10,000 Port Jackson's were manufactured by Aduro using Novatein® IR3020 out of Aduro's single cavity prototype mold and trialled in lamb processors in New Zealand and Australia. Aduro staff were present at all trials which were undertaken across a wide range of flocks from empty to full bellied, lamb and mutton.

Less than 2.0% of the Port Jackson plugs failed to remain in the carcass through to the bung drop station. Anecdotal evidence gathered at processors was consistent that 5% to 15% of the plugs normally used by the processors would fail to remain in the carcass through to bung drop. Aduro's Port Jackson plug was shown to outperform the bungs used by processors in NZ and Australia through retention of the plug and the reduced visible faecal contamination of the carcass. All processors indicated a strong willingness to look at using the plug when it becomes available.

Trials of the Port Jackson in bobby calves received mixed results. The geometry of the plug made insertion difficult in the smaller orifice of the bobby calf compared to ovine. When insertion was successful the plug performed well. Given the relatively low numbers of processed bobby calves compared to lamb it is unlikely the plug geometry will be changed to meet that market.

4.3 Demonstration to the Red Meat Industry.

4.3.1 Cost Benefit Analysis

In October 2014 a new Cost Benefit Analysis was completed by Gareth Forde (ex Lycopodium, now self-employed). This most recent cost benefit analysis published under project code P.PSH.0632 summarizes the findings for a project to manufacture Novatein® in Australia at an undefined location.

It focuses on the volume of resin that would be required to produce the Port Jackson for the Australian market and additional resin required for follow on products that are under various stages of development by Aduro including beef plugs and beef and sheep weasand clips, and posts and containers.

The basis of design is a plant capable of manufacturing 200 kg per hour (kg/h) of Novatein® which will be in a pelletized form suitable for immediate use in injection moulding applications. Using core technical and market data from Aduro (including mass balance, production plant, and product demand data) along with market pricing for equipment, installation and feedstock vendors, capital and operating cost estimates were developed for two scenarios:

- Production of 1000 TPA of Novatein®.
- Ramp up of Novatein® production where demand for polymer to manufacture each product in the first year of production is 15 – 18% of total Australian domestic demand for each specific product with demand increasing according to an exponential trend over the first 4 years to 50 – 60% of total domestic demand. A detailed analysis showing the ramp up of polymer demand is presented in Section 9. Production is ramped up until total annual demand equates to approximately 1000 TPA.

Table 4 below is extracted from that CBA:

TABLE 4 SUMMARY OF CBA OCTOBER 2014

Metric	Novatein® Manufacturing Scenario	
	1000 tpa	Ramp up over 4 years to 1000 tpa
Main plant and equipment cost	$366,727	$366,727
Total capital investment	$1,000,629	$1,000,629
Discounted payback period	0.9 years	4.4 years
Simple present value $/head	$3.04 / head	$2.49 / head
Net present value $/head	$2.18 / head	$1.56 / head
Net present value	$8,735,113	$3,982,977

4.3.2 Presentations to the Australian Red Meat Industry

Aduro has presented to the Australian red meat industry the opportunity to partner with Aduro on several occasions.

In March 2015 where Aduro was invited to attend an MLA workshop (V.COP.0077-2015 Co Products Adoption Industry Workshop). Invitations were extended by MLA to members of the Australian red meat industry to hear presentations on emerging technologies close to market adoption that could be invested in and partnered with by the participants.

Aduro CEO Darren Harpur attended the event and presented on the opportunity for a Novatein® resin production facility to be established in New Zealand in partnership with Aduro. Following this event Aduro and an MLA Innovation Development Manager met with senior staff at JBS Dinmore. This meeting resulted in JBS and MLA working on a separate proposal to aggregate several blood processing technology opportunities

In March 2014 Darren Harpur presented to the joint Australian Renderers and NZ Renders Group conference in Queenstown.

In July 2015 Darren Harpur presented to the Australian Renderers Association Symposium at the Royal Pines Resort on the Gold Coast where the opportunity for the Port Jackson and partnership in a Novatein® resin plant was discussed.

To date whilst there has been strong interest from the red meat industry in products made from Novatein® it has not been matched with a desire to invest in a Novatein® resin production facility. Much of this can be put down to a reluctance to invest in anything that is not core business and processing bloodmeal into a plastic is not being seen as core business to bovine and ovine processors.

5 Discussion

Since 2007 material science research has and continues to be undertaken on Novatein® at the University of Waikato in Hamilton, New Zealand. This background knowledge formed valuable intellectual property going into this project and allowed Aduro Biopolymers research team to foresee and understand future opportunities and possible barriers in developing a commercially viable product from Novatein®. Never-the-less a major challenge facing this project was setting out a product development programme without knowing at the start what product was to be developed. The methodology used in this project proved useful in carefully managing this process to ensure an opportunity was selected where Novatein® could solve problems very few others or no-one else could.

Novatein® is a new and unique bioplastic without commercial precedent. The challenges faced in taking a material like Novatein® through to production of a viable commercial product should not be underestimated. Four key factors must be considered; the economic and technical considerations of how Novatein® resin will be manufactured, selecting a product that creates at least a minimum viable economic opportunity, designing a product that is sympathetic to how Novatein® can be injection moulded, and finally designing a bespoke tool to manufacture the product from Novatein® .

With a product produced from an existing, established commodity or engineering thermoplastic, the engineering follow through for part production and design of tooling would be a routine activity, using specifications for tooling and machine size from the material supplier.

Whilst 10,000 or so Port Jacksons have been made out of a single cavity mold, scaled manufacturing to produce millions of units annually is not a straightforward and routine engineering design problem. Novatein® is a thermoformable biopolymer unlike any biopolymer commercially available today and the specifications for design choices in tooling and plant and equipment specification do not yet exist. A significant technical challenge not included in this project but currently underway by Aduro is the research and development necessary to design and specify injection moulding tooling suitable for processing protein based thermoplastics at a scale sufficient to meet forecast market demand for the Port Jackson.

Tooling design in the plastics industry is usually dependent on the known behaviour of the intended resin which comes from many years of research and development arising from commercial use of the resin in a wide variety of processes and product applications. Modelling based on measured properties can assist in design, but much useful information can only be obtained by experience gained from actually processing specific resins through injection moulding machines and into tools designed specifically for the resin used and product being made. Aduro expects to have completed commercial production trials in its own 8 cavity hot runner tool by late November 2015.

An additional aspect of the technical stretch to enable scaled manufacturing of injection moulded Novatein® parts is how best to produce the resin on a commercial scale. Small scale production of Novatein® 50kg batches of granules for injection moulding has historically involved a separate mixing step, combining bloodmeal with other additives, to produce a pre-extruded intermediate followed by extrusion into granules. Aduro has developed an alternative scalable commercial production technique to feed dry bloodmeal directly into the hopper of the extruder with wet additives introduced in controlled dosages in the barely of the extruder. This dispenses with the need for additional mixing equipment and partially processed feedstock storage, as well as resolving the difficulties with conveying and feeding the preextuded intermediate which is prone to bridging.

6 Conclusions/Recommendations

This project set out to develop a minimum viable product from a new and novel bioplastic with the objective of creating better value for bloodmeal produced by the Australian red meat industry. The product selection techniques and methods discussed in this report could have selected a product to solve a problem in an industry not related to meat processing. This would have meant the sole benefit out of the project would be the conversion of bloodmeal into Novatein® resin. What this project has delivered is a bioplastic material with the potential to solve many of the plastic contamination issues faced not only by Australian meat processors, but those around the globe.

The Port Jackson product developed specifically addresses the strong desire out of the red meat industry for plastic products that are renderable and non-detectable in downstream rendered meals and tallows at a price point that makes a strong case for adoption by the industry.

The final stages of this project concluded that a valid business case can be built around the manufacture of Novatein® and producing the Port Jackson in Australia, given a stringent set of requirements. The business case is sensitive to resin price and product sales, but offers an attractive payback period etc.

Future work will be directed at identifying more products to increase Novatein® resin production. The Australian red meat industry could directly benefit from this project if they would either invest in a resin production facility or indirectly by securing bloodmeal supply to a Novatein® manufacturer. More so, the industry would benefit from reduced plastic contamination in their meals, which may have been an unexpected benefit from this project.

Ongoing development work at Aduro Biopolymers will complete commercial production trials in an 8 cavity hot runner tool by late November 2015. Should those trials validate desktop production and economic modelling Aduro will be in a position to raise new investment for its first commercial scale Novatein® resin plant and injection molding facility to supply Port Jacksons the red meat industry, and Novatein® resin to those who wish to process it.

Aduro views this step as an important validation of Novatein® as a commercially viable bioplastic with the hope that this will transfer into interest from Australian companies, including those within the red meat industry, for establishment of resin production and parts production in Australia. In the meantime Aduro will supply Novatein® resin and/or Port Jackson's to its Australian partner Bestaxx until a sound business case can be made to produce Novatein® and or Port Jackson's in Australia.

Sydney based Bestaxx Innovation is currently supplying several Australian processors with Port Jackson's made from polypropylene out of their own 8 cavity hot runner tool. It is possible Bestaxx will swap to manufacturing those Port Jacksons from Novatein® as soon as Aduro is capable of supplying commercial quantities. This will at least provide the Australian red meat industry with some beneficial outcomes form this project until Australian based Novatein® resin production becomes a viable opportunity for Aduro.