Article

Meat and Wool New Zealand Limited Consortia Research

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Introduction

Meat & Wool New Zealand Limited (M&WNZ) is funded by livestock producers through levies on all beef, sheep and goats slaughtered and wool sold. The income is used to maintain and extend trade access for NZ wool and red meat, and increase its preference both domestically and internationally, and to fund research and development that will help improve NZ farm returns.

On-farm, M&WNZ research looks to support farmers through regional initiatives, education programs and applied research and development in animal health, farm productivity and the environment. Off-farm, M&WNZ works in collaboration with industry and Government organisations, investing in six research consortia, each of which address a number of critical issues for the development of NZ's Beef and Sheep Industry. The consortia are legal entities, with Boards of Directors, who source their scientific expertise from leading NZ providers to ensure the best returns for their shareholders. Largely agriculture and biology-based, the consortia draw on a number of different disciplines to underpin their research, including genetics, animal husbandry, engineering, and chemistry. This review outlines the general work of some of the consortia funded by M&WNZ, including aspects of their chemical research. These consortia are Pastoral Green House Gases Research (PGgRC), Meat Biologics Research (MBC), Ovita, MIRINZ Inc., and Johne's Disease Research. M&WNZ also funds research in wool.

Ovita® - Sheep Genomics

Ovita's goal is to support the sheep industry in developing biological tools that enable farmers to make choices that will best meet the demands made of them, be they geographical, environmental, or market-driven. The key focus is sheep genomics, an area in which Ovita has world-leading expertise. Genetic techniques can be used to address the incidence of parasites and disease, meat yield, and meat quality in animal livestock. The team at Ovita is developing selection tools for the sheep industry based on well characterized traits and proteins discovered from decades of sheep-breeding in NZ.

The organization has successfully commercialised a number of its genetic products for the farming sector through its spin-out company *Catapult Genetics*. Established in June 2006 and recently purchased by Pfizer, Catapult's product list includes:

• Inverdale®, a naturally occurring gene that increases sheep fertility. The Inverdale® DNA test allows farmers to preferentially select animals carrying the Inverdale® gene, and integrate the gene into their breeding programs.

• Shepherd®, which profiles DNA from sires, dams and lambs to generate pedigree and family information. When interfaced with breeding software Shepherd® is used to predict breeding values and genetic indexes. Breeding values are the measure of the genetic value of an animal for a specific trait, while genetic indexes measure the ability of an animal to transmit its genes to the next generation.

• Loin-MAX® and MyoMAX®, DNA tests for selecting animals with increased muscle size. Increased muscling results in less carcass fat and an improved carcass weight compared to animals of the same live-weight and genetic background.

• i-Scan®, a DNA test for Microphthalmia. This is a recessive gene disorder that causes developmental malformation in the eyes of affected lambs and results in blindness. Microphthalmia only occurs when a lamb inherits damaged copies of the gene from both parents. If only one parent has the gene then the animal is a carrier, with normal eye development and function, but capable of passing the damaged gene to the next generation. Blind progeny are an indication of multiple carriers in a flock, for which i-SCAN® can test and guide farmers in breeding decisions to help eliminate the disorder.

• Worm-STAR®, a tool for parasite management. It helps to identify parasite-resistant animals and slow the development of drench resistance.

At the core of Ovita's future developments are SNP (pronounced *snip*) Chips. SNP's are single nucleotide polymorphisms or small genetic changes occurring within a DNA sequence. They occur infrequently - less than 1% of the time in the human population - and are considered most significant when associated with the small percentage of DNA sequences that code for the production of proteins. These have the greatest potential for altering protein biological function. The SNP acts as a marker, allowing segments of DNA to be traced over many generations. The SNP chip brings together thousands of these markers together on one device. The technology can then be used to accurately select animals for traits that are important for efficiency and profitability, including disease resistance, meat quality attributes, maternal ability, and other factors that are not easily measured in an animal until later life. Breeding values (as noted above, the measure of the genetic value of an animal for a specific trait) are traditionally determined over multiple generations. However, SNP's have the ability to accurately predict breeding values for new-born animals, for which no previous data exist. The long term prospects for the application of this technology are extremely promising, offering the potential to help eradicate diseases such as facial eczema,

reduce drenching frequencies, significantly increase lamb survival rates, and (ultimately) the overall quality of NZ lamb meat.

Wool Research

M&WNZ investment in wool is focused on maintaining the profile of NZ wool with international users of the fibre. With textile processors having an ever increasing array of fibre options to produce their products with, a key strategy for M&WNZ is to keep wool as a viable textile fibre choice. Ensuring a continuous stream of new innovation in wool products is core to the future of wool as a fibre. Our investment is focused on maximizing wool fibre quality, developing technologies that enable new and improved performance wool products to be introduced to the market, and addressing areas of market risk, including research to improve lightfastness, insect resistance, and chemical residue identification.

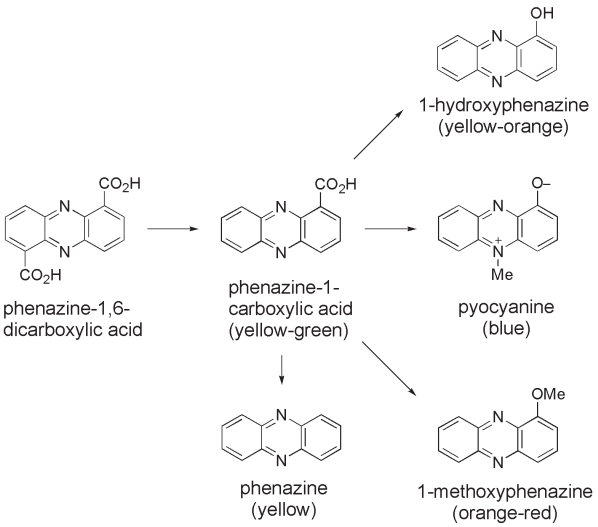
Wool Discolouration

Prior to dyeing and processing, wool is washed in hot water and detergent to remove the non-wool contaminants. This process is known as scouring. The quality and value of the wool is detrimentally affected by the presence of colour that is not extracted from wool during the scouring process.[1] Intense yellow discoloration on a sheep is often associated with warm humid temperatures when fungal and bacterial organisms thrive in the wool fleece. This colour is not removed by conventional scouring methods. Knowing the origin and identity of the compounds causing the discoloration is vital in understanding how to treat the discolored wool. Scientists at AgResearch found the yellow discoloration to be associated with the wool cuticle and identified the compounds responsible as phenazine-based chromophores, including 1-hydroxyphenazine, pyocyanine, and phenazine-1-carboxylic acid (Scheme 1). Phenazines form the structural basis of the azine dyes such as eurhodines, indulines, and safranines. There are over fifty naturally occurring phenazines, whose microbial production is limited to a few bacterial genera, the most prominent of which is *Pseudomonas*. *Pseudomonas aeruginosa* is a widely studied phenazine-producing bacterium that is a ubiquitous member of wool fleece microflora. It is often the dominant species when the fleece is wet and is thought to be associated with the ovine dermatological condition, fleece rot. Biosynthesis of a range of coloured phenazines, including those identified in the wool cuticle, has been proposed to start with phenazine-1,6-dicarboxylic acid, as shown in Scheme 1.

Having identified the chromophores responsible for fleece discolouration, the researchers are now investigating commercially viable treatments for removing the phenazine-related colour from the wool. Simple treatments, such as reduction with sodium hydrogen sulfite both pre- and post-scour, have already been demonstrated as effective, causing substantial improvements in whiteness of the wool without any observable damage to the fibre.

Metal Free Wool Dyeing

With some synthetic fibers guaranteeing up to ten years lightfastness or fade resistance, the challenge to improve

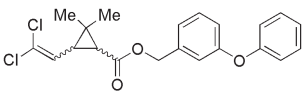


Scheme 1. Phenazine Chromophore Biosynthetic Pathway

lightfastness of woolen fibers is crucial for NZ wool in international markets. Metal-free dying techniques, developed by scientists at AgResearch, are a significant breakthrough for the industry.[2] To enhance the lightfastness of conventional woolen dyes, small amounts of cobalt- and chromium-containing dyes are traditionally used for colouring carpets. The new dyes do not contain heavy metals but form pigments inside the wool fibres to achieve significantly higher lightfast qualities than conventional wool dyes. They are also more environmentally friendly than their predecessors, an important attribute for effluent discharges from wool mills. The research program has progressed through concept and experimental stages to full-scale industrial trials in Europe, with plans for two major European companies to launch the product commercially in mid-2008 if the trials are successful.

Insect Resistance

A problem unique to wool fibre is its susceptibility to attack by certain moths and beetles.[2] The broad-spectrum insecticide, permethrin, which has traditionally been used to treat woolen carpets for insect resistance, is no longer environmentally acceptable as it is highly toxic to aquatic organisms, killing the invertebrates and affecting the growth of insects that fish feed on. Strict international effluent discharge standards for the insecticide are having a profound impact on the industry, particularly in European cities where multiple carpet mills can be discharging effluent to one sewage treatment works. Developing a long-term non-insecticidal treatment was important in maintaining the carpet industry's international competiveness.



permethrin

Again AgResearch Limited scientists have met this challenge and developed a new set of carpet protection agents. Their first initiative was the development of a new generation insecticide effective in producing insect-resistant carpets, but with a low environmental impact on waterways. Mystox is now in commercial development with Catomance Technologies Ltd., a UK based industrial technology company. More recently, the team at AgResearch

has taken a different approach by creating two biodegradable treatments for carpets that are not insecticides. These treatments bind to wool fibre in much the same way as a dye would and prevent the insects from eating the carpet, but they do not kill them. The treatments do not break down in light as insecticides do, and once they have been shown to be fast with regard to shampooing and light exposure, have the potential to be successful commercial products for insect resistance. Spin-off benefits have also resulted. The agents used in the treatments are also excellent dye bath leveling agents (they ensure the fibres dye evenly without streaking) and may, in addition, have potential applications in the apparel industry.

Nanotechnology

Nanotechnology[3] is being used to create high performance textiles for the wool industry. Inert nanoparticles attach themselves to wool fibres, increasing fibre friction and blocking dirt. *Lanasan NCF* (Nano Carpet Finish) developed in 2005 by scientists at AgResearch and commercialised with Swiss multinational Clariant is one such treatment. The carpet is treated with the nanoparticles during the dyeing or final yarn washing stage to produce a high performance carpet with strong yarn and a stable pile. Manufacturers see an 80% improvement in yarn strength that reduces shedding, fuzzing and pilling, and therefore the need to vacuum. The tiny particles attach themselves to the wool, making the pile more robust and increasing the ability to withstand short-term wear by up to 20% and doubling long-term resistance. The particles also prevent soil from attaching itself to the carpet, improving the soil resistance of the final product.

There are also options to apply nanotechnology to other textiles, with high performance clothing and upholstery applications currently under development. In one particular application gold nano-particles are being used as stable colour-fast colourants on wool. As the colour reflected from a gold nano particle is highly dependent on the size and shape of the particle, red, purple, yellow, green, and blue colours can be created by controlling the finish on the textile. While organic dyes break down in sunlight, gold-dyed fibres benefit from gold's relatively inert properties and show improved fade resistance.

Pastoral Greenhouse Gas Research Consortium (PGgRC)

Greenhouse gases (GHGs) and their role in global climate change is extremely topical, in NZ and globally. It is widely acknowledged that human activities are altering the composition of the atmosphere. In NZ 48% of GHG emissions come from agriculture. The Pastoral Greenhouse Gas Research Consortium (PGgRC) represents a key investment by the NZ livestock and pastoral industries in mitigating GHG emissions from the agricultural sector. The consortium aims to decrease the total emissions of greenhouse gases in NZ 10% by 2013 (relative to 2004), estimated to be a 4 Mt reduction in the agricultural GHG emissions.

Two greenhouse gases are associated with pastoral agriculture: methane and nitrous oxide. The majority of methane is belched from ruminant animals as a by-product of rumen fermentation, while nitrous oxide is formed as part of the nitrogen cycle in pastures when soil conditions are anaerobic, particularly in winter when soil moisture and water tables are high (Fig. 1).

Fig. 1. Measuring gas emissions from sheep

Methane Reduction

Methane is the by-product of the digestion of forage by micro-organisms in the rumen of an animal. Digestion produces hydrogen, which is converted by methanogens in the gut to methane. Therefore, the inhibition or elimination of methanogens is a major focus of the methane GHG reduction strategy for pastoral animals. This presents a significant scientific challenge as altering the ruminal ecosystem to reduce methane emission can have profound effects on animal health, farm management and animal productivity. Developing successful intervention strategies to reduce methane emissions depends heavily on understanding rumen ecology and the parameters that influence animal productivity. The PGgRC research programme includes research in genetic sequencing and identification of methanogen species and populations, dietary effects on ruminant methane, the effect of animal variation on methane production, development of a methanogen vaccine, and the identification of a chemical inhibitor for methane production.

A significant breakthrough for PGgRC in 2008 has been the mapping of the genetic sequence of the methanogen, *Methanobrevibacter Ruminantium*, a world first for the NZ team (Fig. 2).[3] The microbe is a member of a major group of rumen methanogens, having more than 2200 genes, but at 3 million bases in size is considered of medium size. The genome sequencing research project aims to identify new genes and proteins that can be used to target and inhibit methanogens, without decreasing animal productivity or affecting the many other microbes that are beneficial to the rumen and digestion. While there is still a long way to go to reduce methane emissions, closing this genomic sequence is seen as an important piece of a complex puzzle.

Nitrous Oxide Emission Reduction

The greatest source of nitrous oxide emissions result from the dung and urine deposits of grazing animals (94%), while the remainder comes from nitrogenous fertilisers. Nitrous oxide is formed by the actions of soil bacteria, during either the oxidation of ammonium ions to nitrate or the reduction of nitrate to nitrogen gas. Mitigation strate-

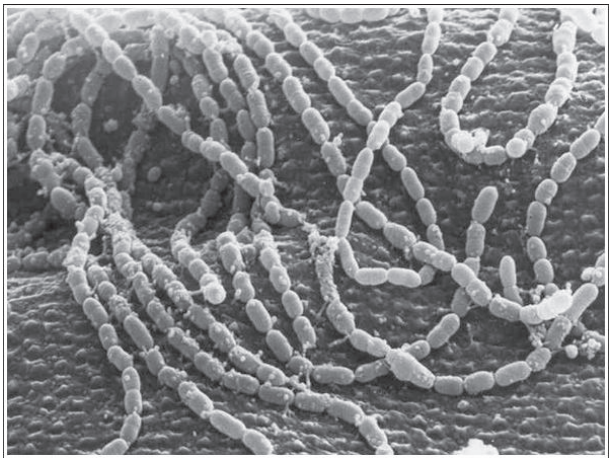
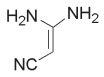


Fig. 2. Methanogen string

gies for nitrous oxide include both on-farm management and science-based solutions. Removing animals from wet pasture and collecting their excreta for later application to dry pasture, controlling the amount of nitrogen added to the soil from fertiliser, and ensuring farmers use low nitrogen feed supplements all actively reduce nitrogen accumulation in the soil. Farm system management tools are invaluable in applying these strategies, with programmes such as OVERSEER™ providing practical nutrient budgeting models for use on-farm. Nitrification inhibitors, compounds that inhibit the conversion of ammonium to nitrate, provide a science-based nitrous oxide mitigation strategy. One nitrification inhibitor, Dicyandiamide (DCD) has successfully passed proof-of-concept tests in short-term, small- to farm-scale testing and has been commercially available for several years. Research continues on proving the long term effects of inhibitors and to accurately account for the effect of this mitigation strategy at paddock scale.



dicyandiamide
DCD

Meat Biologics Research Consortium (MBC)

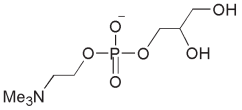
The Meat Biologics Research Consortium was established in 2002 to develop novel nutraceuticals, functional foods and health supplements from red meat or red meat co-products. These bioactives are targeted for use by humans for general health and well-being, and have been developed around specific, strategically selected, market opportunities, ultimately aimed to increase the value of NZ meat. The consortium is currently focused on a small number of products that show potential for commercial development, including a treatment for iron deficiency and a protein supplement.

Iron Deficiency

The WHO estimates that 1.3 billion people in both developed and developing countries suffer from iron deficiency.[4] Those at risk include people suffering from chronic parasite infestation, weaning babies, young adolescent girls, and women in menstruation. Iron deficiency is a widespread, generic issue. The use of red meat to enhance iron uptake and bioavailability has been well established in the scientific literature[5] and has come to be known as the *meat factor*.

A team at Massey University, funded by MBC, is one of several groups globally that are attempting to identify the active compound in meat which is responsible for enhancing iron absorption from the diet. Chemical fractionation procedures are complemented by an array of *in vivo* and *in vitro* testing that guide the team to a successful conclusion.

The hunt for the meat factor has spanned 40 years of research. Despite extensive studies demonstrating the enhancing effect of meat on iron absorption, the mechanism of the effect remains controversial and none of the research has unequivocally identified the active component or components responsible to date. Fatty acids,[6] peptides arising from the proteolytic digestion of meat[7] and the amino acids histidine, cysteine, and to a lesser extent, lysine[8] have all been implicated as playing a role in the meat effect. The most recent publication in the area has identified L-α-glycerophosphocholine (L-alpha) as an ingredient contributing to iron uptake from the diet.[9] L-alpha was isolated from digested meat samples following separation by fast protein liquid chromatography and identification using a combination of mass spectrometry, nuclear magnetic resonance and HPLC. When added to vegetarian lasagna, L-alpha has been shown to increase iron absorption in women of child-bearing age with low iron stores.



L-α-glycerophosphocholine

Protein Supplements

Protein is an essential part of the human diet and is required for cell maintenance and repair and a wide range of bodily functions. Low consumption of protein may lead to muscle wasting and increased susceptibility to infection. In particular, in physiological states such as malnutrition in the elderly, sports nutrition for endurance training, weight training or body building, pregnancy, or malnutrition, the provision of a high quality protein supplement with the appropriate balance of amino acids can be a significant aid to protein retention or synthesis.

Protein supplements can be provided either as native protein or with the protein already partially digested (hydrolysed). Digestion typically begins in the stomach by pepsin and is continued by trypsin and chymotrypsin in the intestine. The protein is broken down progressively, until – on reaching the ileum – most of the protein is in the form of amino acids or small di- or tripeptides. These amino acids and small di- and tripeptides are then absorbed by the cells lining the gastrointestinal tract. Once inside the cell most of the absorbed di- and tripeptides are digested into amino acids by cytoplasmic peptidases and exported from the cell into blood. Thus provision of protein already in the form of the small peptides ready for absorption can enhance both the degree of and speed of absorption.

As well as displaying rapid and complete absorption, a good protein supplement should provide the body with essential amino acids in balanced proportions. Overall protein synthesis will be limited if any particular essential amino acid is present at a lower concentration than that required for protein synthesis. Amino acids should also be bioavailable so that their absorption achieves the required balance in the body.

A wide range of protein supplements is available commercially, many of which are sourced from casein. In order to make an impact in the protein market, MBC is developing a range of highly characterised meat proteins with potential applications in the personalized food arena, where foods are tailored to meet the individual preferences and health needs of a consumer. The meat hydrolysates are high quality, highly digestible forms of amino acids, which have an ideal composition very similar to that of human muscle. With the growing global trend to providing consumers with scientifically supported foods that address specific nutritional and health issues, MBC's range of meat hydrolysates can be tailored to provide the correct balance of amino acids for consumers, be they elderly patients or professional body builders.

Johnes Disease Consortium

Johne's disease (pronounced *yo-knees*) is a contagious, chronic and sometimes fatal infection that affects the small intestine of ruminant animals including cattle, sheep, goats, and deer. Discovered in 1905 by the German bacteriologist and veterinarian Heinrich A. Johne, the disease is caused by the bacterium *Mycobacterium paratuberculosis* and is widespread throughout the environment in many countries. In NZ the bacterium has been isolated from a range of wildlife, including rabbits, hedgehogs, ferrets, hares, cats and gulls. Overseas, animals such as foxes and various marsupials have been shown to carry the bacteria. The disease is spread by animals eating infected pastures and drinking from infected waterways; infection of an animal normally occurring shortly after birth. The onset of symptoms, however, may not occur until an animal is between 2 and 6 years old. As there are limited diagnostic tests available for Johne's disease, farmers and vets often have to rely on verification of infection post-mortem. Johne's is progressive; starting with diarrhea and wasting and leading to the animal becoming increasingly emaciated and dying from dehydration and severe malnutrition. The effect of the disease is costly, with impacts on animal health and production estimated to cost up to $88 million each year in this country.

The Johne's Disease Research Consortium (JDRC) has been developed to unite and accelerate research into the disease in NZ aiming to develop efficient and effective tools to control and reduce its prevalence. Four significant developments are the focus of JDRC research. The first is to develop diagnostic tools for farmers and vets that enable identification of infected animals. Leading on from this is effective management systems for on-farm control of infected herds. The third and fourth developments are preventative in focus, looking to create a new vaccine and identify possible gene markers for resistance to the bacteria. Vaccines are currently available for Johne's but these can have side effects and may affect the result of tuberculosis testing. Genetics, however, may hold the long term key to this disease if researchers are able to identify a gene-marker that does not compromise production and which will allow farmer to select for Johne's resistant stock.

MIRINZ Inc. - Meat Processing

MIRINZ Food Technology and Research (MIRINZ Inc) aims to increase the profitability of NZ meat processors by focusing on increasing the value of the animal carcass and accompanying quantity of sales, while reducing the costs associated with meat processing. It is possible to increase the returns from an animal carcass by upgrading the worth of low value meat cuts. It is well accepted that the degree of animal stress prior to slaughter influences meat quality, but quality is most significantly affected by the post-slaughter processing of the carcass, with the effects of pH and meat cooling accounting for up to 70% of the final quality of a cut.

During processing, various changes take place in the biochemical and structural attributes of muscle tissue in the meat, especially when meat transforms from a pre-rigor mortis to a post-rigor mortis state. During rigor mortis a carcass stiffens as muscles shorten and the muscle pH falls. Good quality meat is associated with lower muscle pH, as at high pH meat is darker and less desirable to customers, and also runs the risk of increased meat spoilage. The application of an electric current to the carcass after slaughter (electrical stimulation) reduces the pH of the muscle quickly and hastens the onset of rigor mortis, optimising meat quality. Smart Stimulation is an on-line measurement tool and tailored stimulation system co-funded by MIRINZ Inc. and Meat and Livestock Australia (MLA) to improve pH control on the processing chain. The system has the ability to measure the pH of the carcass easily and efficiently and, as a result, administer a tailored electrical input to the carcass to ensure consistent meat quality. MIRINZ Inc. is also co-funding the development of an NMR-based online tool to measure pH further down the processing chain to predict tenderness, with initial trials showing promise.

Tenderness can also be affected by stretching meat prior to rigor mortis. Stretching improves tenderness and also positively influences the colour of the meat and reduces drip loss. Drip retention is important for retaining tenderness and juiciness in a cut of meat. The Boa Meat Stretcher is a new device for stretching meat, which was developed with co-funding from MIRINZ Inc. Industry trials of a *pre-production unit*, have successfully improved the shape and tenderness of lower quality meat cuts.

Through such initiatives and other automation technologies under development MIRINZ Inc. is helping to bring improved productivity and value to the NZ meat industry. MIRINZ Inc. also has a role in maintaining existing markets for NZ meat. While meat has traditionally been shipped to international markets frozen, there is a high demand for fresh, chilled, NZ product. Such meat must be protected from spoilage by organisms and pathogens or risk rejection by importers. One new initiative under de-

velopment by is the addition of lactic acid bacteria (LABs) to meat during chilling. *Brochothrix thermosphacta* is the predominant spoilage organism in chilled raw meats. As the organism grows at temperatures between 0°C and 30°C and thrives in depleted aerobic conditions, refrigeration and vacuum packing provide ideal conditions for growth. Lactic acid bacteria have the ability to inhibit spoilage by growing faster than undesirable organisms, such as *Brochothrix thermosphacta*. This work will help secure the future of NZs excellent international safety reputation.

Conclusion

The agricultural sector plays a lead role in underpinning the NZ economy. Meat and wool exports earned us approximately $6000 million in 2006-07, so ensuring that we remain at the forefront of scientific advancements in agriculture is vital for our economy. Through its participation in Research Consortia, M&WNZ is actively investing in the future of the NZ beef and sheep industry. That support extends across a broad range of activities, but is consistent in its approach, securing first class research from the country's scientific community for the benefit of the NZ farmer and the economy as a whole.

Acknowledgements

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New Zealand Science Scene

Big Future in Vaccines

New adjuvants, the helpers in making vaccines effective, are currently being worked on at Industrial Research Limited in Lower Hutt.

Science teams led by Gavin Painter and Phill Rendle, have discovered two new compounds they believe could be effective adjuvants. The ideal adjuvant needs to be potent, non-toxic, water soluble, biodegradable and stable.

The possible compounds currently being worked on by IRL come from a bacteria and a plant. The first works by cell-mediated immunity. A synthetic version of the plant derivative has been developed with Otago University's School of Pharmacy.

The word adjuvant comes from the Latin verb adjuvare meaning *to help*. Often without the help of adjuvants, the immune response to a vaccine is small. Vaccines are composed of one or more antigens and one or more adjuvants. The adjuvants enhance the immune recognition of the antigens and increase the immune system's ability to make antigen-specific antibodies. They can also, among other things, reduce the need for booster vaccines.

There are only a few adjuvants licensed for human use. Many of the common ones are aluminium salts first used in the 1930s. Adjuvants are a rapidly growing area of research. This is because more is understood about immunological mechanisms and there are new technologies helping the research. Also, organisations like The World Health Organisation have set ambitious goals for using vaccination in disease control.

An effective adjuvant can mean a cheaper vaccine because less active ingredients need to be included for it to trigger a response. It can also be used to improve vaccines that previously failed in trials.

Gavin Painter and Phill Rendle using IRL's newly upgraded spectrometer to analyse adjuvant samples.

It is possible in the future there maybe vaccines for chronic diseases like cancers and auto immune diseases and for diseases that affect thousands around the world such as malaria or tuberculosis. A vaccine for cancer is already being developed in a collaboration between IRL, Grow Wellington, Victoria Link and the Malaghan Institute. IRL is providing an adjuvant.