

Plant & Food  
**RESEARCH**

RANGAHAU AHUMĀRA KAI



The New Zealand Institute for Plant & Food Research Limited

# Sports performance & recovery – the science

**Roger Hurst**  
**Science Group Leader, Food & Wellness**  
**Food Innovation**

# Sports products – what can berries offer?

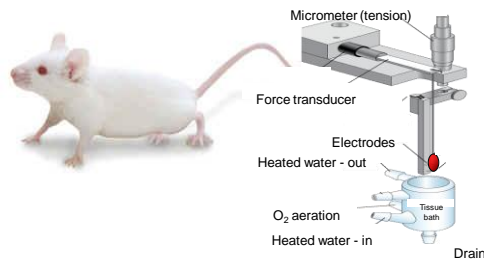
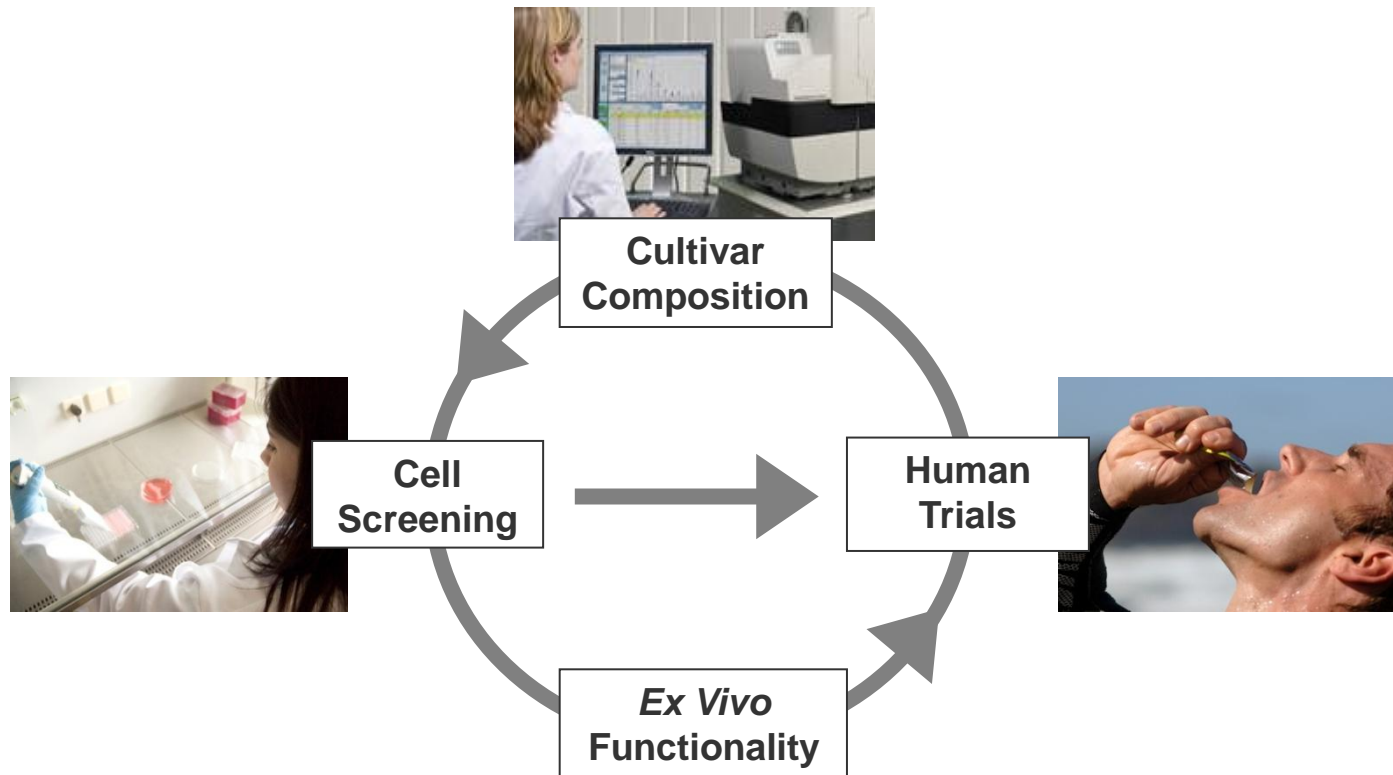
Consumer benefits in sports products:

- » Controlling Stress
- » Less Damage/Pain
- » Speedier Recovery
- » Train for Longer/Harder
- » Enhanced Performance
- » Reduced Risk of Infection

**‘Enhancing the natural  
benefits of exercise’**



# Sports performance & recovery – approach



# Berryfruit composition – an opportunity?

Blackcurrant samples for anthocyanin and phenolic analysis

Cultivar	Year	Sample	Code	Anthocyanins						Phe-nol	Cyan-rutinoside	Antho Total
				Del-glucoside	Del-rutinoside	Cyan-rutinoside	Link	antho				
<p style="text-align: center;">Other</p> <p>479, 175 209 Caffey 341 Caffer 593 341 C 235-p-Cou 81 p-Cou25-p-Cou46 Link 522 341 C673 341 1377 Ulnok40 481 287 d339 Link 385 223 548 287 d391 Link 465 Link 625 479 3479 317 1436 Link 521 317 1391 link 403 Ulnok47 301 1463 301 C235-p-Cou463 301 402 161 p-505 285 K449 287 d593 317 M447 285 1463 317 M477 Link 465 Link 481 295 U</p>												
B11	2008/2009 2nd	B11	32.9	129.2	84.2	5.1	3.1	2.4	2.0	269		
B11	2008/2009 2nd	B11	30.5	119.8	80.0	4.5	3.0	2.2	2.0	251		
B15	2008/2009 2nd	B14	31.4	127.8	83.5	4.0	2.2	2.3	1.9	263		
B15	2008/2009 2nd	B14	37.2	153.2	135.5	1.8	0.9	2.3	1.3	342		
Bakewell	2008/2009 2nd	B17	25.3	69.8	71.4	3.7	2.1	1.1	1.9	195		
Ben Ad	2008/2009 gem	B011	27.1	130.0	120.9	5.7	3.4	2.1	1.1	286		
Ben Ad	2008/2009 village 2	B181	27.4	121.3	109.9	5.3	3.4	2.1	1.2	271		
Ben Doran	2008/2009 2nd	B19	23.0	86.6	84.0	4.5	2.6	1.9	1.7	189		
Ben Doran	2008/2009 2nd	B19	20.9	77.4	65.5	4.1	2.3	1.7	1.1	163		
Ben Hope	2008/2009 gem	B17	18.1	76.4	62.4	4.0	2.6	1.3	1.2	166		
Ben Hope	2008/2009 gem	B18	28.2	108.0	88.8	4.8	2.8	1.8	1.4	234		
Ben Lomax	2008/2009 gem	B142	17.2	74.9	54.6	4.2	2.9	3.8	2.5	190		
Ben Raa	2008/2009 gem	B014	18.3	103.1	105.4	6.8	3.7	1.8	1.5	204		
Ben Raa	2008/2009 B	B182	18.2	131.0	123.9	6.4	3.7	2.0	1.2	286		
Blackadder	2008/2009 2nd	B008	30.7	117.9	117.5	3.5	2.2	2.2	1.1	275		
Blackadder	2008/2009 2nd	B13	31.54	147.01	112.51	3.17	2.3	2.3	1.2	271		
L053	2008/2009 2nd	B018	30.5	114.2	111.3	5.1	2.9	1.3	0.9	256		
L053	2008/2009 2nd	B061	18.2	86.0	80.2	4.1	2.4	1.3	0.7	212		
L070	2008/2009 comm	B188	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0		
L18	2008/2009 2nd	B18	21.5	65.8	74.5	3.7	2.2	1.3	0.8	160		
L18	2008/2009 2nd	B20	18.2	63.2	48.2	3.1	1.8	1.1	1.3	153		
L21	2008/2009 2nd	B169	28.8	133.7	126.8	2.8	1.1	1.2	1.9	184		
L424	2008/2009 2nd	B029	25.1	91.6	80.2	3.4	2.3	1.4	1.0	185		
L424	2008/2009 2nd	B074	31.4	142.0	147.2	2.4	1.4	0.4	0.2	162		
L502	2008/2009 2nd	B058	23.2	90.1	79.0	5.0	2.8	1.4	1.7	203		
L502	2008/2009 2nd	B184	20.3	73.9	63.7	4.1	2.5	1.0	0.7	166		
L513	2008/2009 2nd	B026	26.7	92.8	80.2	4.2	2.7	1.3	0.8	219		
L513	2008/2009 2nd	B095	25.6	74.8	69.0	3.2	2.0	0.8	0.9	172		
L515	2008/2009 2nd	B022	31.0	95.4	101.0	4.5	2.8	1.4	0.9	237		
L515	2008/2009 2nd	B131	30.8	97.5	103.7	4.8	3.0	1.5	1.0	242		
L517	2008/2009 2nd	B124	32.9	150.9	97.3	4.3	2.4	2.5	2.1	292		
L517	2008/2009 2nd	B198	26.9	104.7	79.8	3.6	2.1	2.2	1.8	209		
L601	2008/2009 2nd	B019	31.1	86.0	89.1	3.4	2.2	3.7	1.8	197		
L601	2008/2009 2nd	B092	27.6	145.2	92.0	2.9	2.0	3.3	1.6	155		
L603	2008/2009 2nd	B012	31.7	144.7	94.1	5.7	3.3	2.5	2.0	294		
L603	2008/2009 2nd	B019	26.1	128.8	79.5	1.8	2.1	2.2	1.8	208		
L604	2008/2009 2nd	B130	27.6	129.8	128.2	4.0	2.1	1.7	1.2	295		
L604	2008/2009 2nd	B189	30.0	137.1	127.7	4.2	2.2	2.3	1.5	305		
L605	2008/2009 2nd	B017	25.5	104.8	67.5	5.8	3.1	1.4	1.4	211		
L605	2008/2009 2nd	B166	25.8	93.4	80.3	5.1	2.8	1.7	1.1	200		
L606	2008/2009 2nd	B170	24.6	99.4	78.4	4.1	2.7	1.6	1.0	212		
L609	2008/2009 2nd	B007	44.3	116.0	130.1	3.7	2.4	1.8	2.0	300		
L609	2008/2009 2nd	B138	43.7	115.0	119.3	3.8	2.2	1.9	2.4	307		
L610	2008/2009 2nd	B009	34.1	89.4	78.2	3.2	1.8	0.4	0.2	204		
L611	2008/2009 2nd	B024	25.5	87.7	72.5	4.3	2.6	1.1	0.7	194		
L613	2008/2009 2nd	B071	18.4	92.5	87.6	3.3	2.1	1.2	1.4	207		
L614	2008/2009 2nd	B040	21.2	69.6	85.5	4.6	3.0	1.8	1.0	219		
L614	2008/2009 2nd	B108	24.5	113.1	95.7	5.1	3.2	2.0	1.1	245		
L617	2008/2009 2nd	B024	24.9	124.8	119.4	3.2	2.0	1.5	1.0	277		
L617	2008/2009 2nd	B134	25.6	118.0	111.9	3.4	2.1	1.6	1.1	264		
L618	2008/2009 2nd	B017	36.9	152.8	100.4	5.3	2.9	1.7	0.8	298		
L619	2008/2009 2nd	B025	36.3	129.4	100.5	5.5	3.2	1.5	0.8	277		
L619	2008/2009 2nd	B068	12.4	55.8	63.1	3.4	2.5	0.7	0.6	139		
L621	2008/2009 2nd	B134	35.1	89.6	72.6	4.4	2.6	1.5	1.6	207		
L623	2008/2009 2nd	B174	26.1	147.7	89.2	4.2	2.5	1.8	1.2	239		
L623	2008/2009 2nd	B178	24.0	104.7	86.3	3.9	2.4	1.6	1.1	224		

Over 1000 berryfruit cultivars analysed : Total anthos, % anthos, Total phenolics (Hplc & Folin), ORAC, FRAP, Vit C

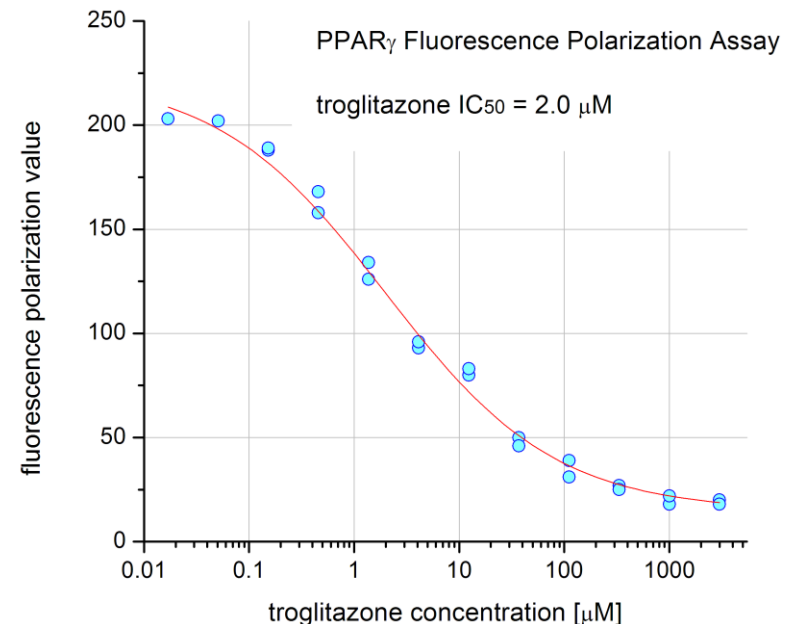
## Underpinning future opportunities – unique cultivars, unique products



# Cell-based assays – physical health

## Physical health assays:

- » Direct toxicity to muscle cells
- » Oxidative stress protection  
– protection against ox stress
- » Oxidative protection  
– heat shock protein expression
- » Oxidative protection  
– mitochondrial ROS
- » Anti-inflammatory assay  
– IL6 and TNF generation
- » Adaptive anti-oxidative measures  
– e.g. SOD, catalase

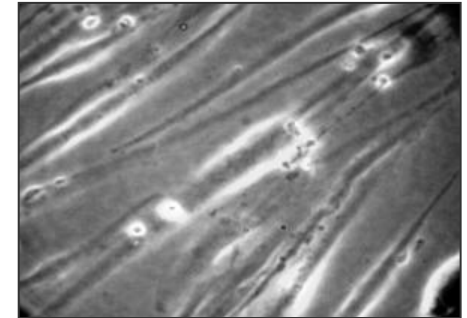


**A platform for cell-based physical health ‘evaluation’**

# Cell-based assays – immunity and inflammation

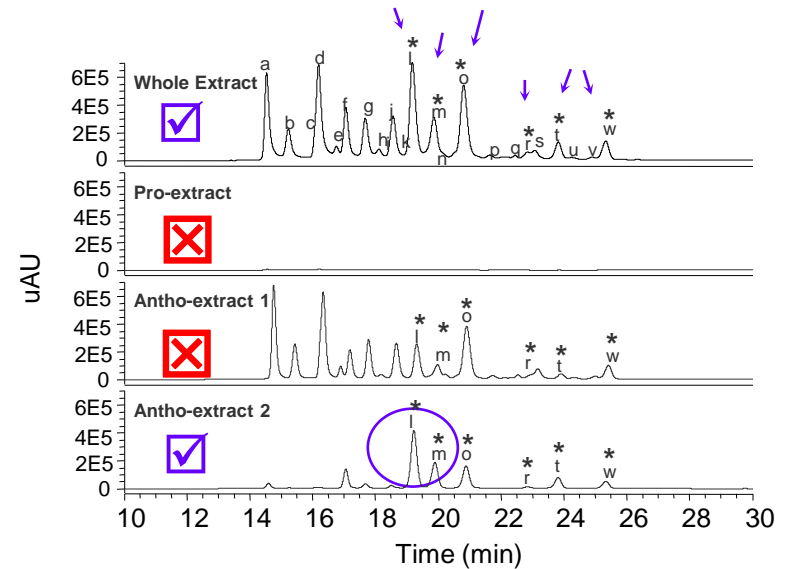
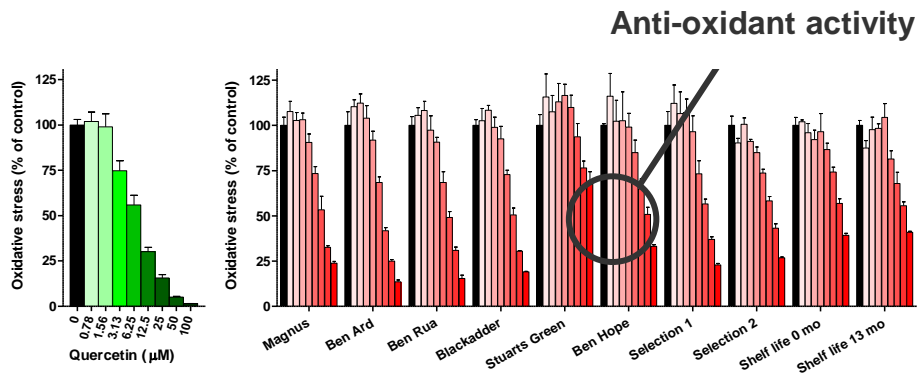
## Immunity/Inflammation assays: (cell, whole blood)

- » Modulation of cytokine, signalling mol. generation – various cells
- » Nuclear factor (NFkB) gene activation/inhibition
- » Induction of cytokine gene expression
- » Natural killer cell activity – whole blood and cell lines
- » Phagocytosis
- » Neutrophil oxidative burst
- » T cell subset activation – flow cytometry
- » Glucose uptake, lipid accumulation – adipocytes, muscle cells
- » Lymphocyte Oxidative stress protection



**A platform for cell-based immunity and inflammation ‘evaluation’**

# Cell-based assays

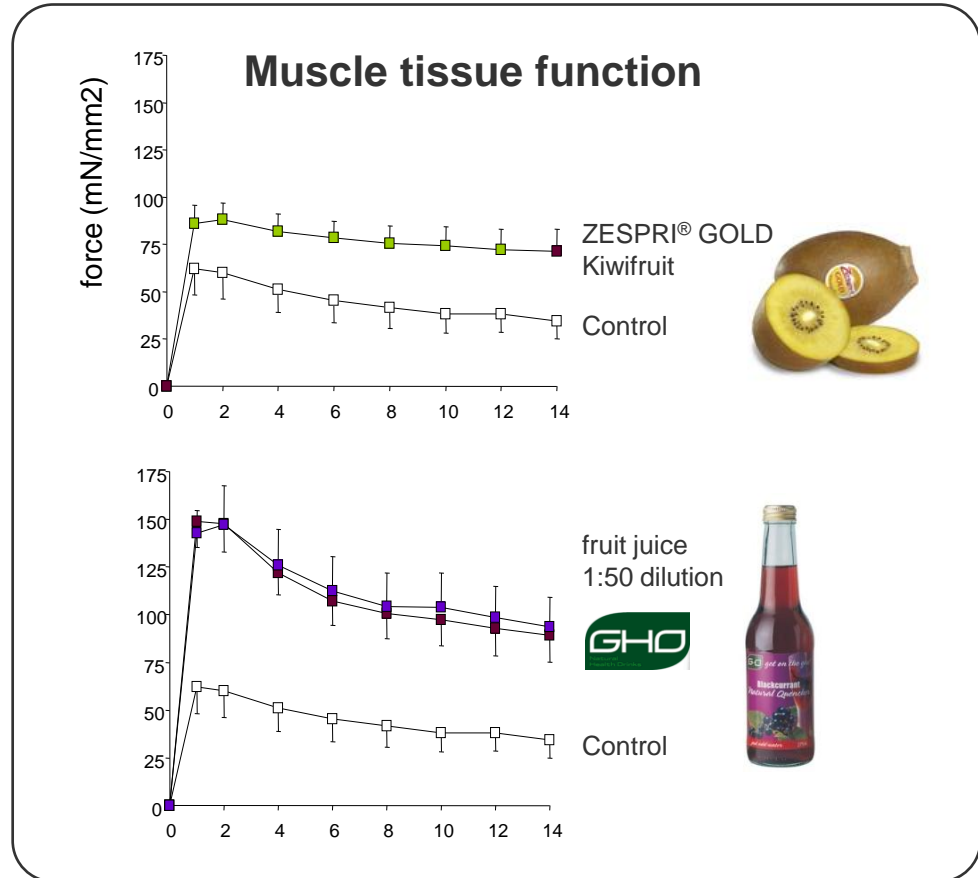
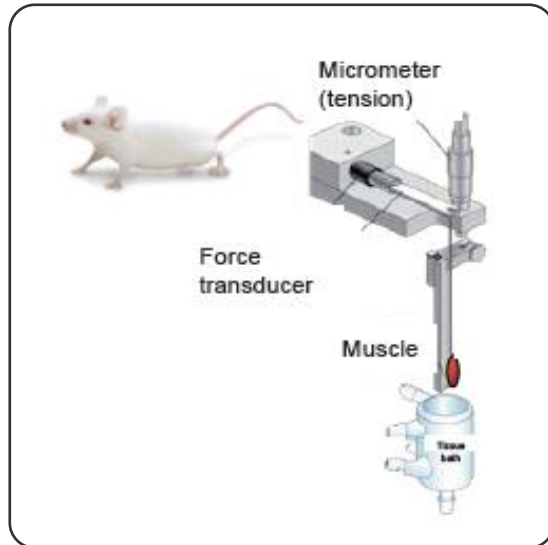


## Guidance on best genotypes and actives

R.D. Hurst, R.W. Wells, S.M. Hurst, T.K. McGhie, J.M. Cooney and D.J. Jensen (2009) Blueberry fruit polyphenolics suppress oxidative stress-induced skeletal muscle cell damage in vitro, *Mol. Nutr. Food Res.* 53, 1-11.



# Muscle function – ex vivo modelling



R.D. Hurst, R.W. Wells, S.M. Hurst, T.K. McGhie, J.M. Cooney and D.J. Jensen (2009) Blueberry fruit polyphenolics suppress oxidative stress-induced skeletal muscle cell damage in vitro, *Mol. Nutr. Food Res.* 53, 1-11.

Skinner, M.A., Hunter, D.C., Denis, M., Parlange, N., Zhang, J., Stevenson, L.M., & Hurst, R.D. (2007) Health benefits of ZESPRI GOLD Kiwifruit: effects on muscle performance, muscle fatigue and immune responses. *Proc. Nutr Soc of NZ*, vol 31, 49-59.

Schrage, B., Stevenson, D., Wells, R., Lyall, K., Holmes, S., Deng, D., & Hurst, R. (2010) Evaluating the health benefits of fruits for physical fitness: A research platform. *J. Berry Res.* 1, 35-45.



# Human exercise models

Rowing



30 mins, 80 % max heart rate

**Oxidative stress**

Repeat quadriceps squats



4 sets of 10 repeats, 3 min rest between repeats  
– to failure -

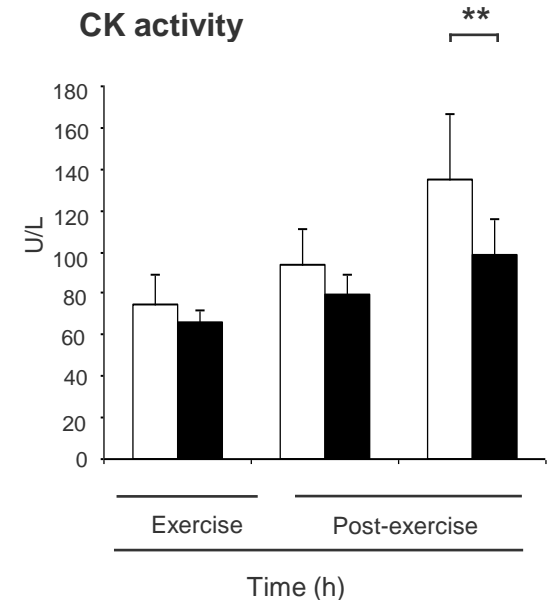
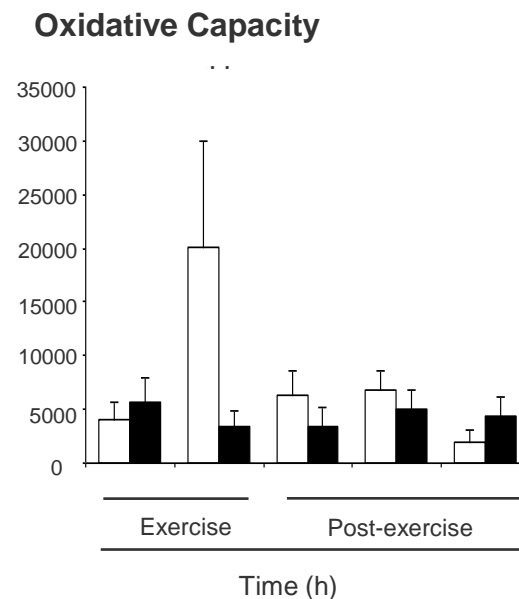
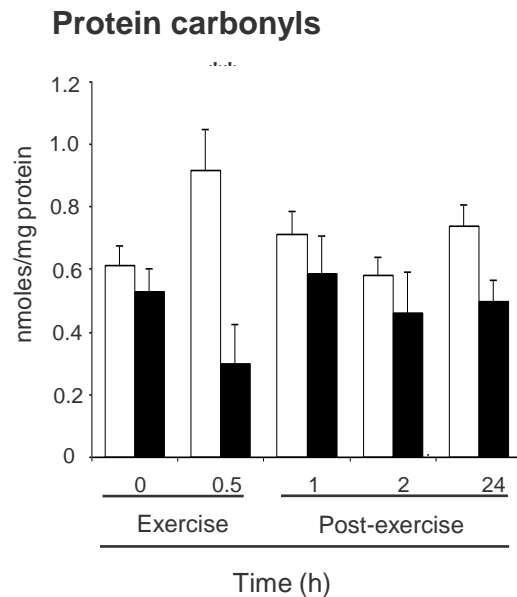
**Muscle damage**

New Zealand blackcurrant powdered extracts evaluated

**A platform for human-intervention ‘evaluation’**

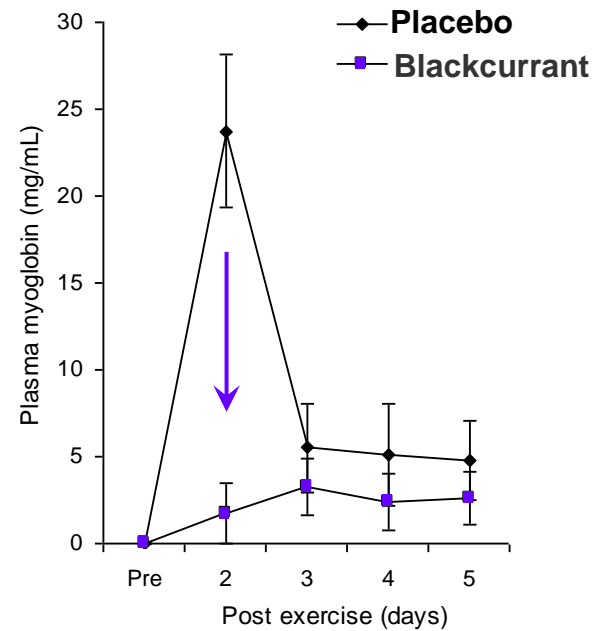
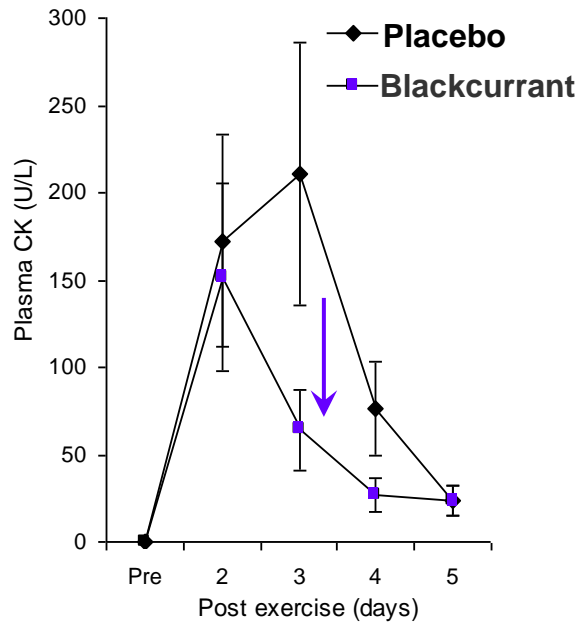
# Human exercise – blackcurrant Oxidative stress model

- N=8 volunteers
- Double-blind, cross-over
- 30 min rowing exercise at 80% max ♥ rate
- 240 mg total anthocyanin



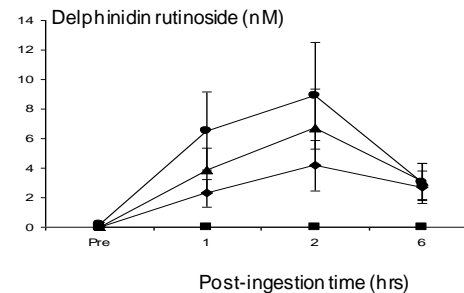
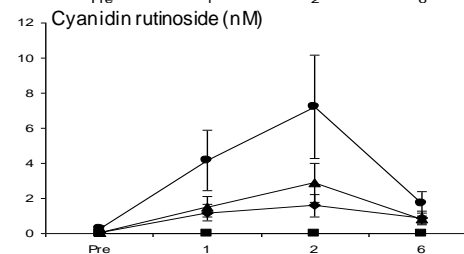
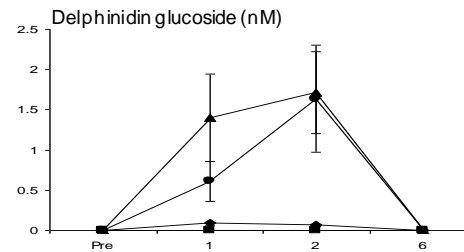
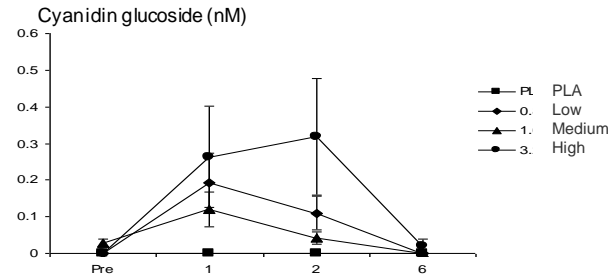
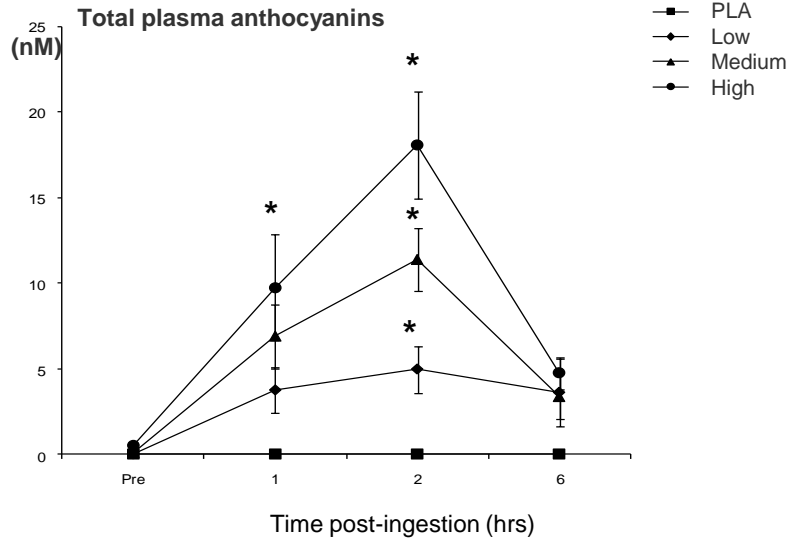
Blackcurrant modulated exercise-induced oxidative stress and muscle damage

# Human exercise – blackcurrant Muscle damage model



Blackcurrant prevents muscle damage – long term action

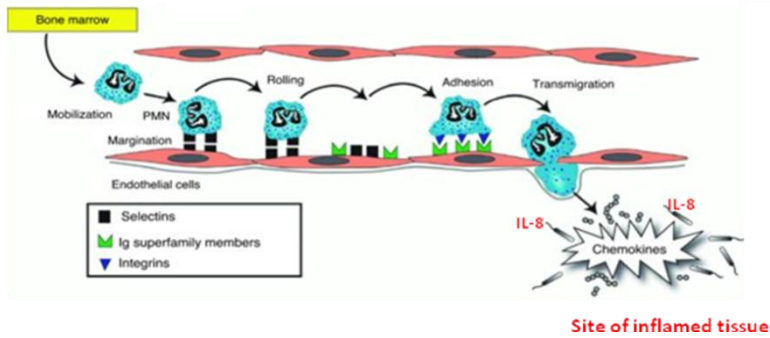
# Blackcurrant anthocyanin bioavailability – which dose ?



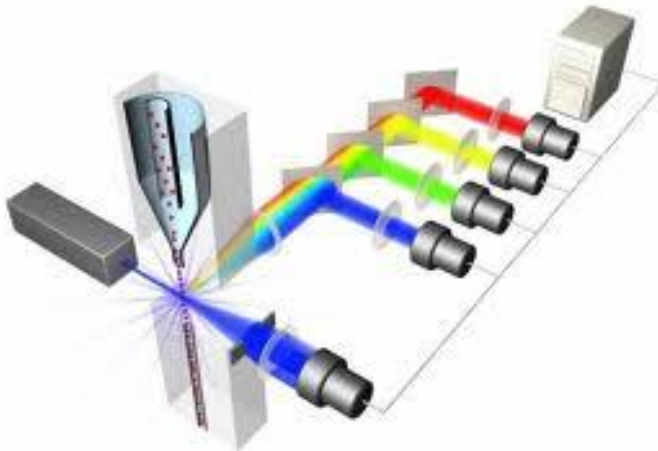
- » Optimum dose determined
- » Peak post consumption determined



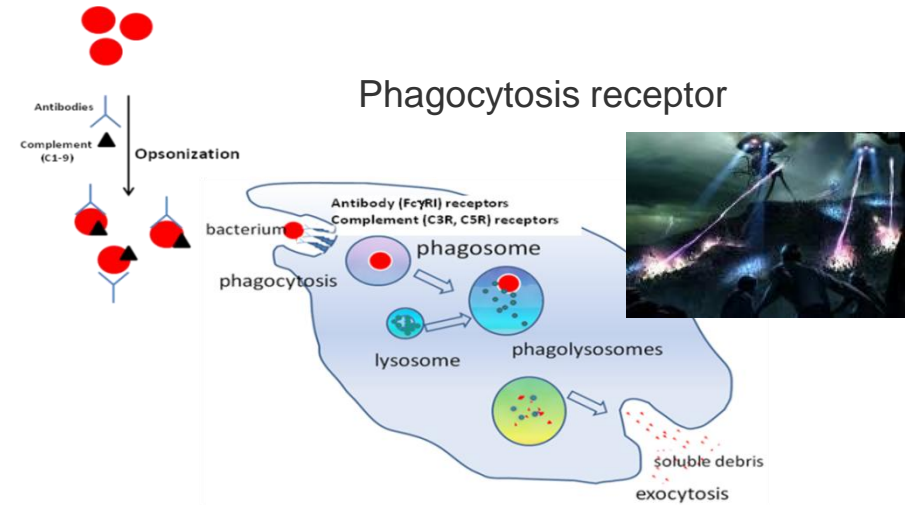
# Immunity – neutrophils – first line of defence



Recruitment receptors



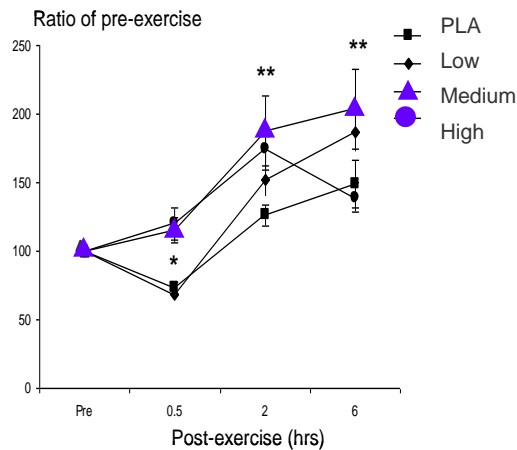
Phagocytosis receptor



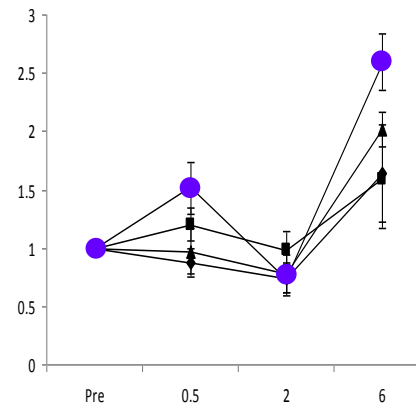
# Neutrophil receptors & function

## – effect of blackcurrant (WITH EXERCISE)

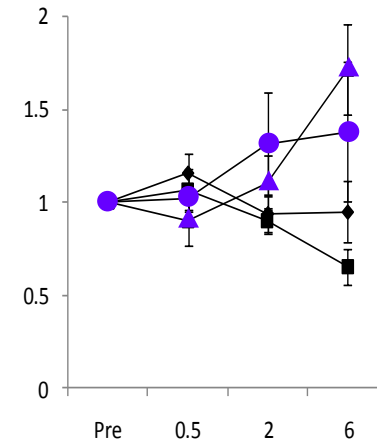
Neutrophil recruitment



Phagocytosis receptor



Bacteria being eaten



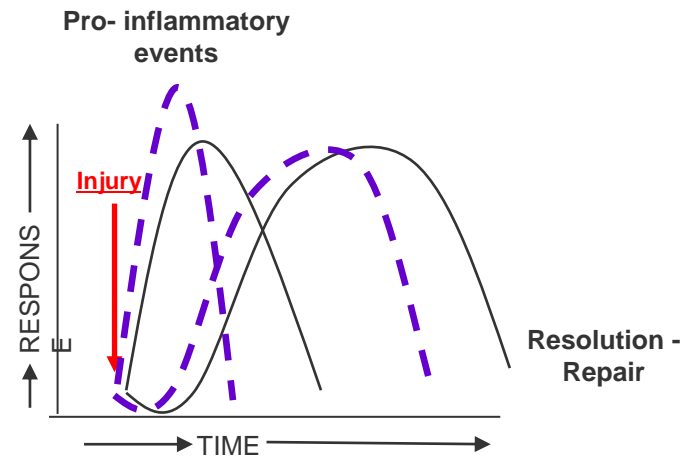
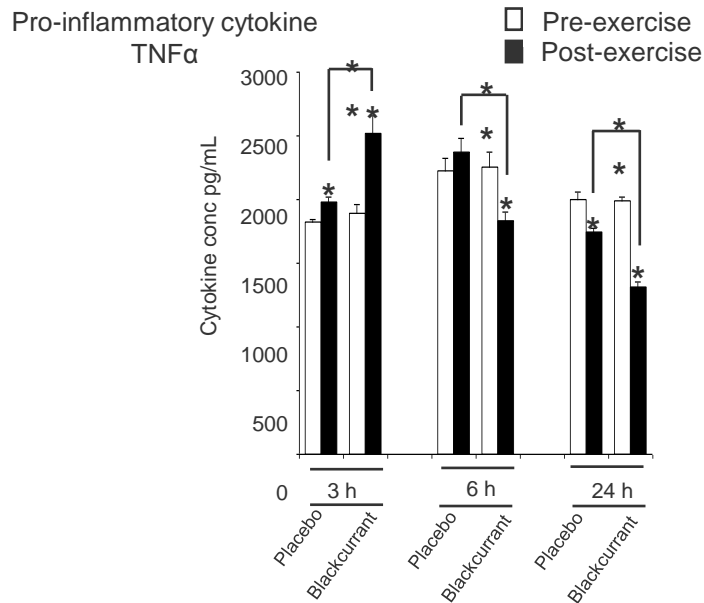
- » Neutrophil cell receptors enhanced by blackcurrant
- » Neutrophil killing bacteria function increased

**Immune assistance – fight infection/tissue repair**  
**Assists the natural benefits of exercise**



# Human exercise – blackcurrant – immunity

**Plasma applied to monocytic cell line, challenged with bacterial toxin (LPS)**



Augmented acute inflammatory response

Increased ability to respond to pathogens

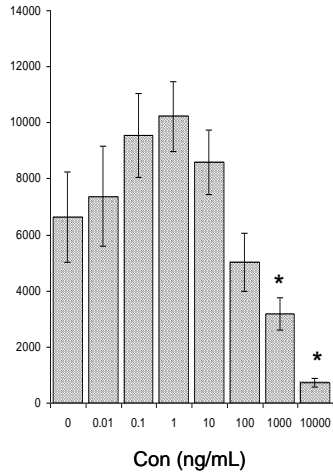
**Earlier resolution - quicker repair**  
**Assists the natural benefits of exercise**



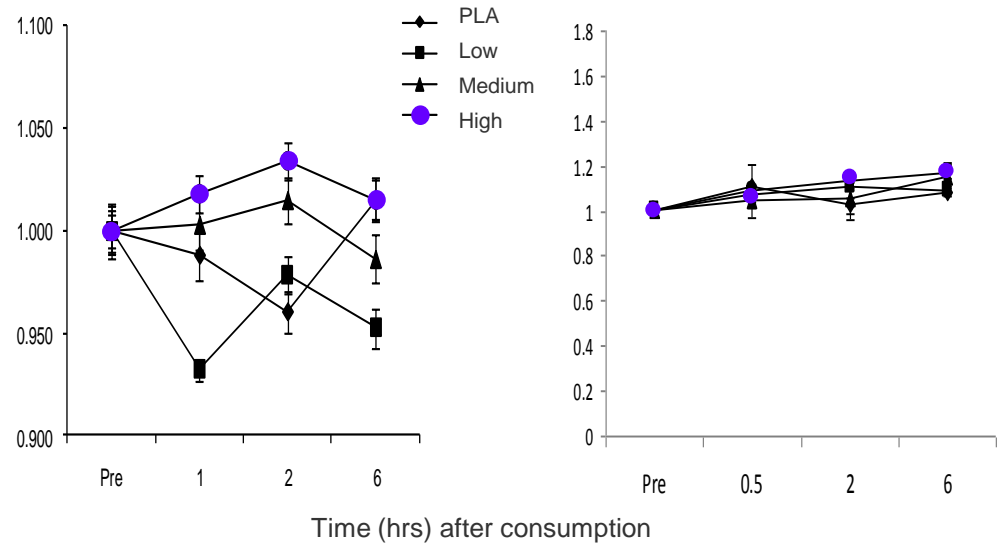
# Mechanism of action?

Lab antioxidant test

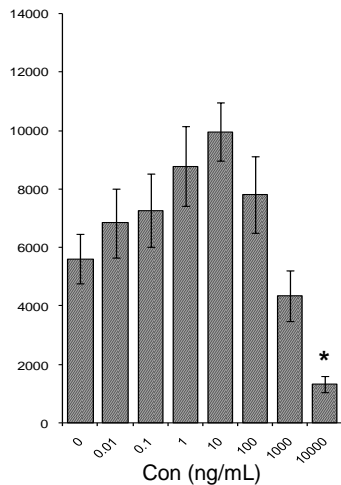
Product 1



Plasma antioxidant status



Product 2



- » Products are similar – strong antioxidants
- » Action very unlikely to be ‘antioxidant’
- » Good insights on action & actives (not shown)

# Why is this important?

- » Good evidence for 'assisting the natural benefits of exercise & sports' for New Zealand blackcurrant
- » Good evidence of functionality, dose, timing, actives, likely mode of action



# Commercial benefit

Soft marketing claims backed by science (not anecdotal):

- » Controlled oxidative stress and inflammation
- » Controlled muscle damage and soreness
- » Assisted immune protection - enhanced immunity
- » Speedier tissue repair, recovery and performance in exercise
- » Train/work harder .....and for longer



# People with 'involvement' in the specific work shown

Kieran Elborough – General Manager Science

Roger Hurst – Programme Leader

Deborah Tod/Carl Massoratto – Business Managers



Suzanne Hurst  
Jeff Greenwood  
Shanthi Parkar  
Harry Martin  
Jing Yuan  
Kirsty Lyall  
Robyn Wells  
Selena Holmes

David Stevenson  
Dwayne Jensen  
Geoff Langford  
Cath Snelling

Other support  
Industry support

Janine Cooney

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