

# Anthocyanin-Rich Supplementation: Emerging Potential for Sport and Exercise Nutrition

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Institute of Sport, Nursing and Allied Health

University of Chichester

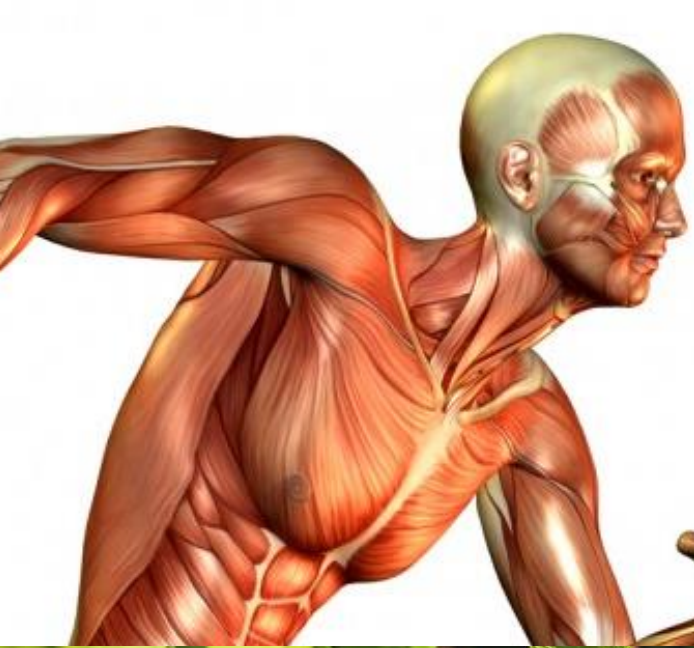


United Kingdom



July 21, 2023

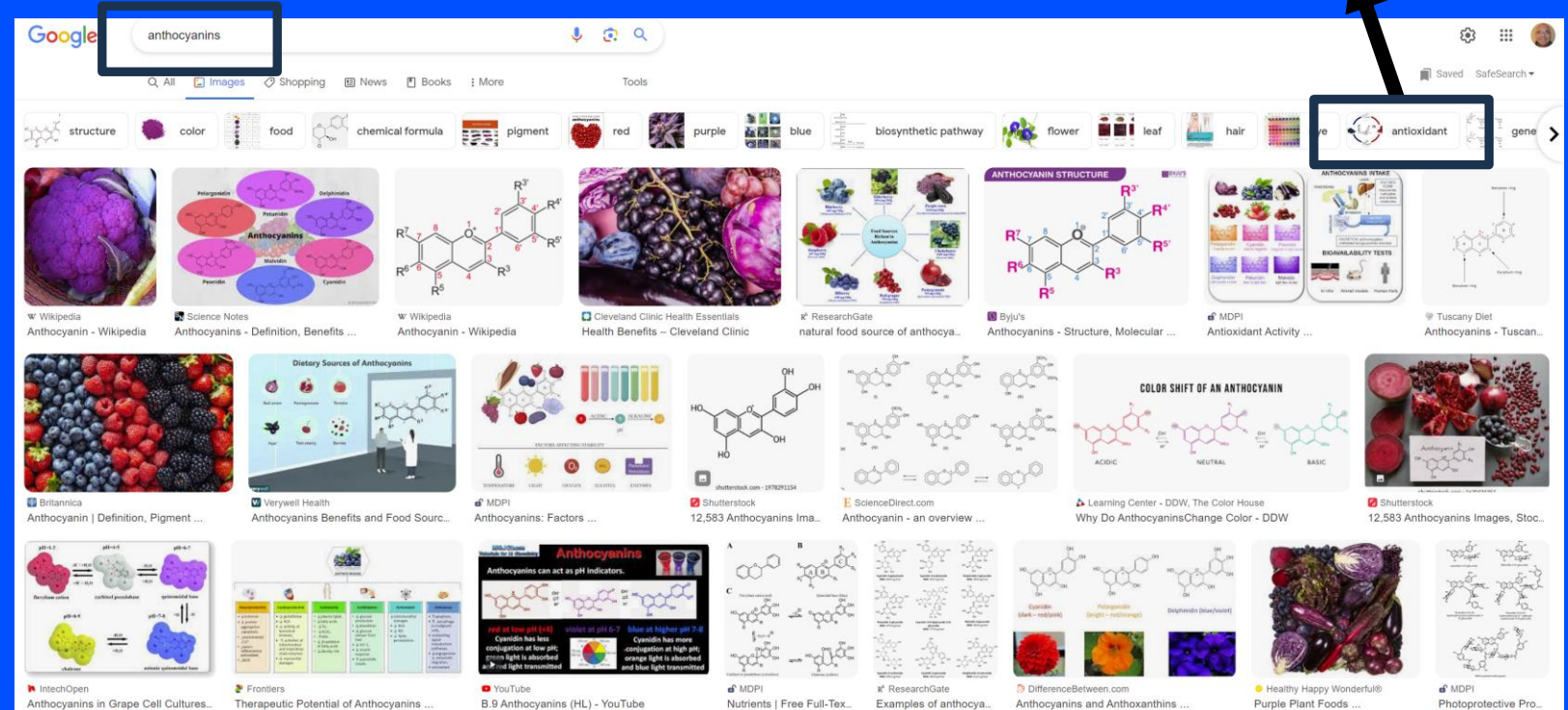




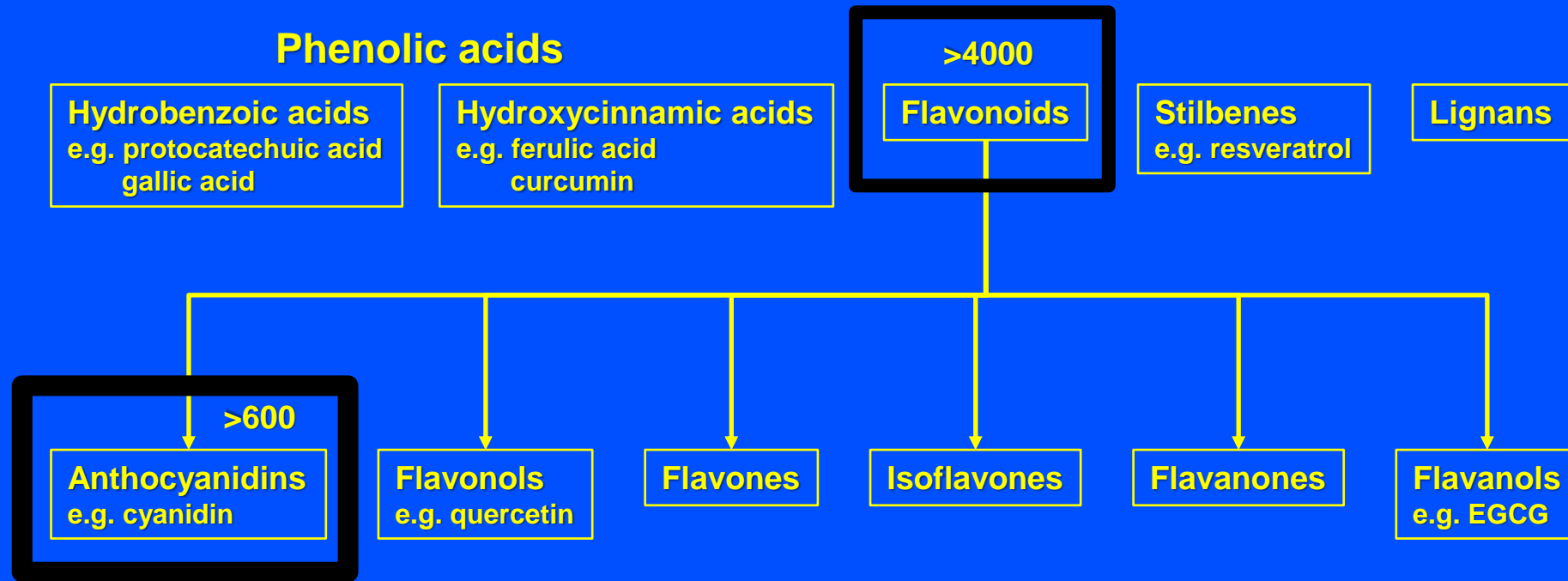
# Anthocyanin-Rich Supplementation: Emerging Potential for Sport and Exercise Nutrition

anthocyanins

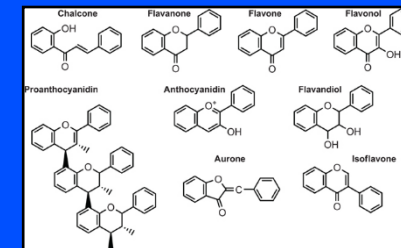
antioxidant



# Polyphenols (>8000)



anthocyanins are glycosides of anthocyanidins  
e.g. cyanidin-3-glucoside







black  
elderberry



black  
chokeberry



blackcurrant



bilberry



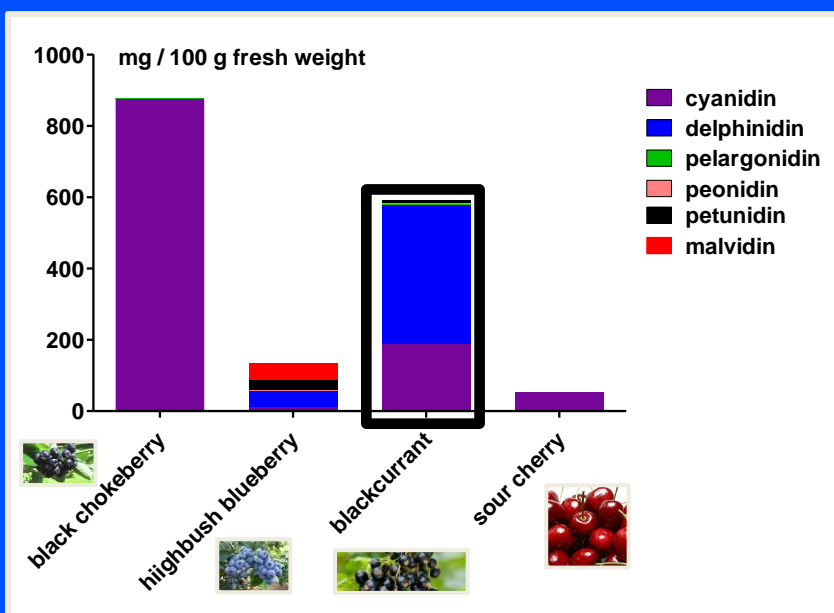
highbush  
blueberry



strawberry

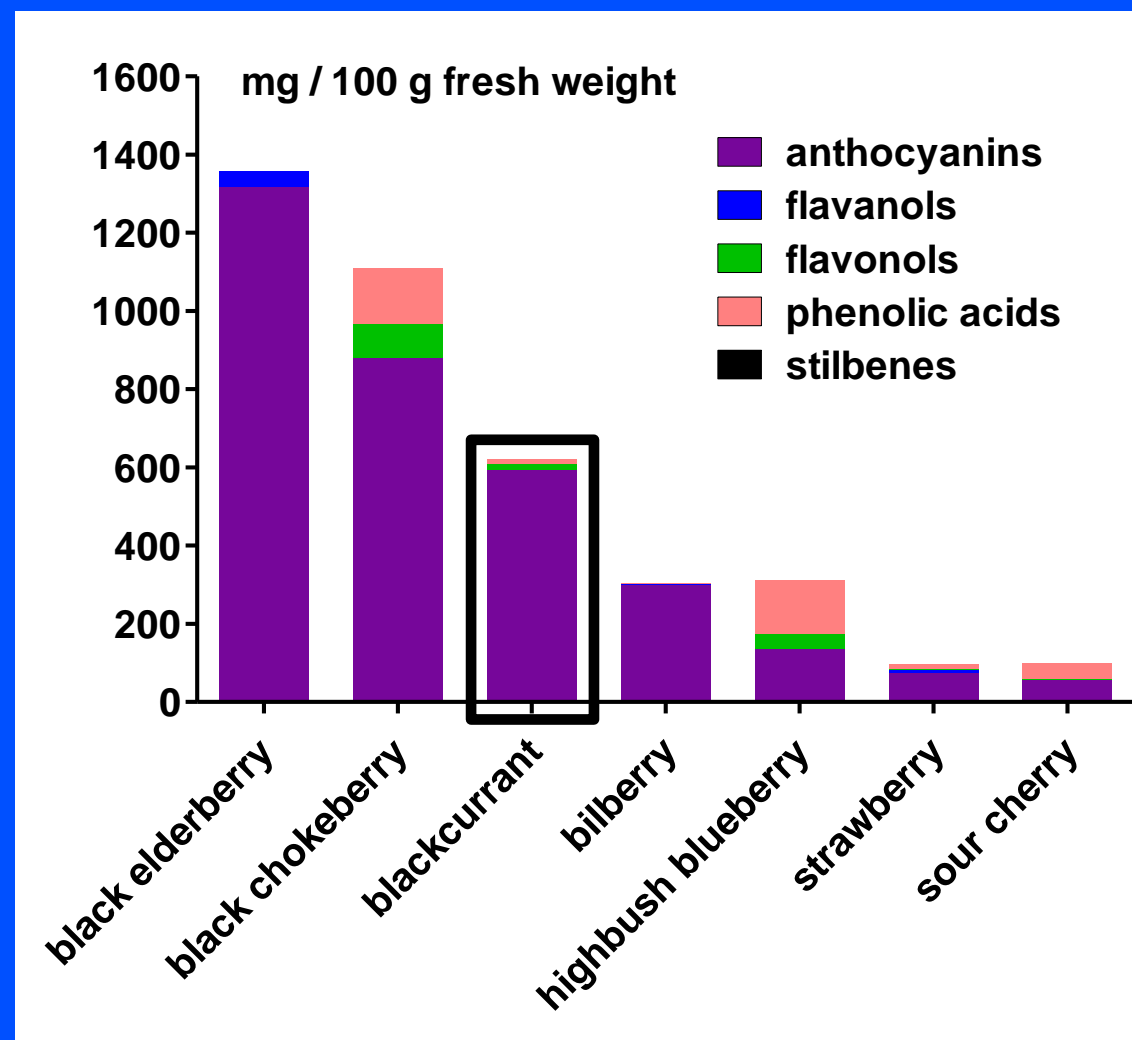


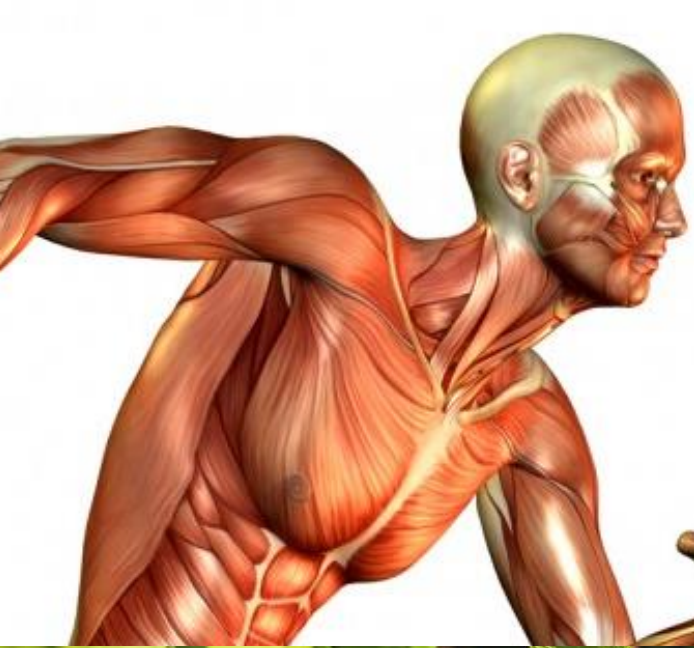
sour cherry



Berries differ in total anthocyanin  
content and composition

# Polyphenol composition





# Anthocyanin-Rich Supplementation: Emerging Potential for Sport and Exercise Nutrition

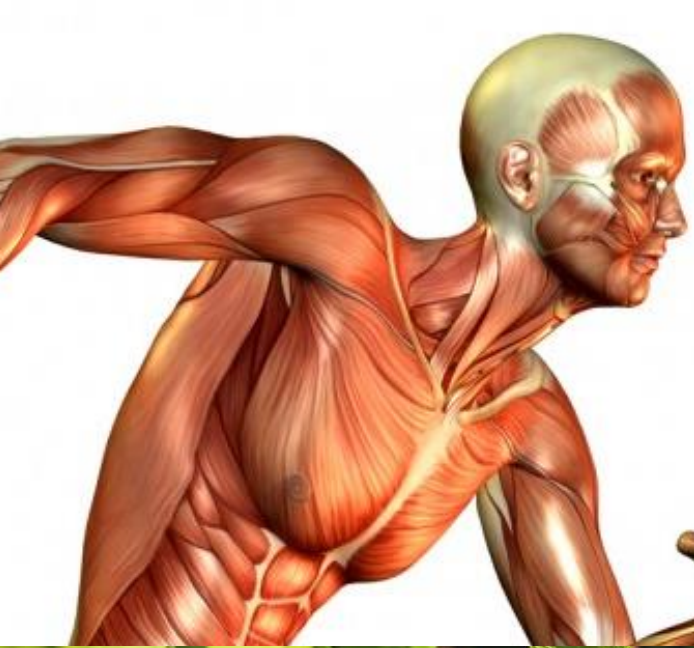
## Outline

- Why the interest in anthocyanin-rich supplementation?
- Exercise performance and metabolic effects by anthocyanin intake
- Future directions: We are not there yet?



**Anthocyanin-rich blackcurrant  
intake as the leading example**





# Anthocyanin-Rich Supplementation: Emerging Potential for Sport and Exercise Nutrition

## Outline

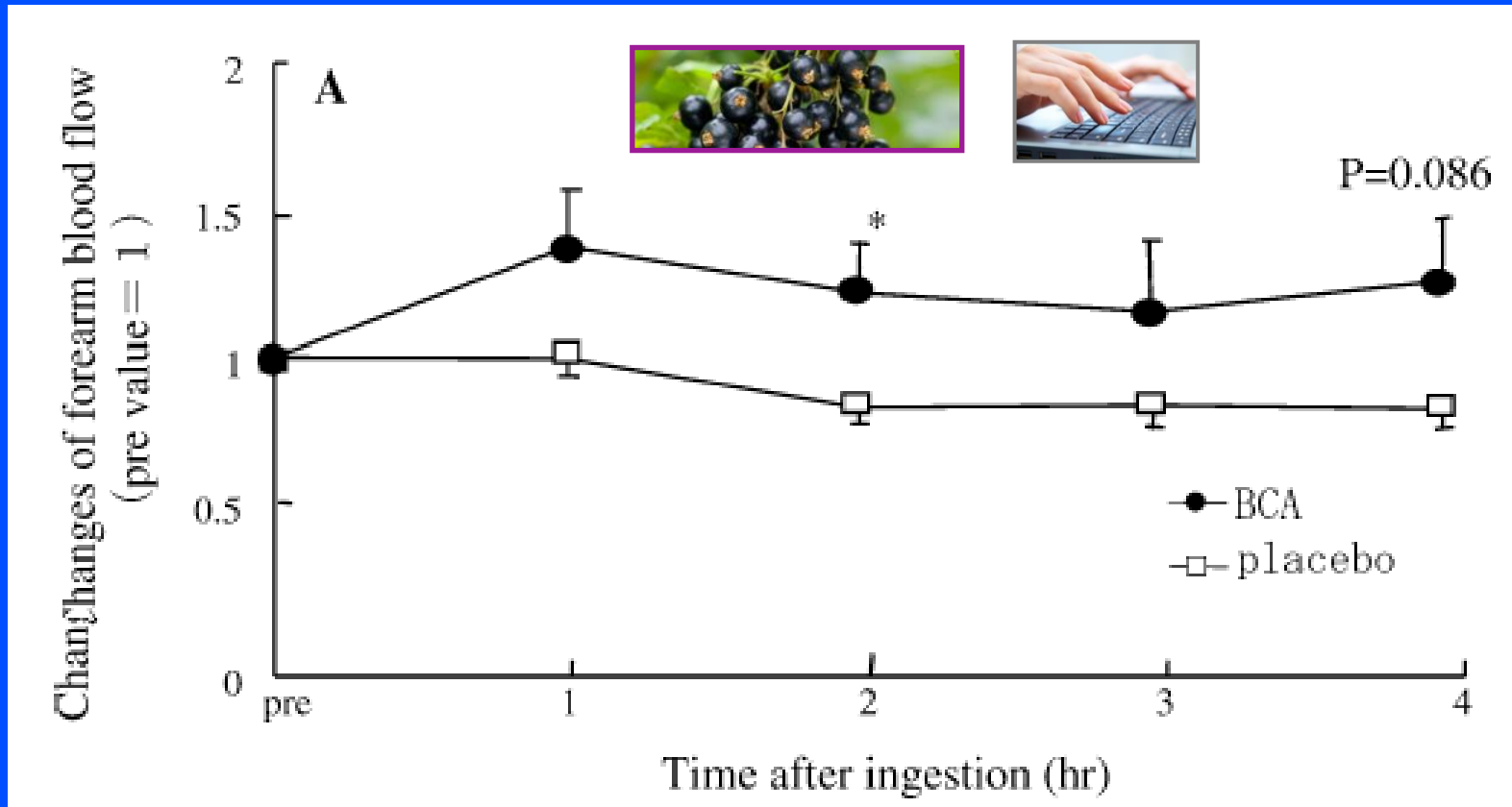
- Why the interest in anthocyanin-rich supplementation?



**Anthocyanin-rich blackcurrant  
intake as the leading example**

# Effects of blackcurrant anthocyanin intake on peripheral muscle circulation during typing work in humans

blackcurrant anthocyanin concentrate  $17 \text{ mg (kg BW)}^{-1}$  10.83% anthocyanins



2005

8 males

3 females

age:  $39 \pm 12 \text{ yr}$

Forearm blood flow  
(supine position)

Near infrared spectroscopy

blackcurrant-induced increase in blood flow by 22% (2 hr)

# peer-reviewed < 2013: Only one paper!

PubMed.gov

blackcurrant AND exercise



Search

Advanced Create alert Create RSS

User Guide

Found 1 result for blackcurrant [ti] AND exercise

Filters applied: From 1900 to 2013/12/31. Clear all

Clinical Trial > Am J Physiol Regul Integr Comp Physiol. 2009 Jul;297(1):R70-81.  
doi: 10.1152/ajpregu.90740.2008. Epub 2009 Apr 29.

**Short-term blackcurrant extract consumption modulates exercise-induced oxidative stress and lipopolysaccharide-stimulated inflammatory responses**

K A Lyall<sup>1</sup>, S M Hurst, J Cooney, D Jensen, K Lo, R D Hurst, L M Stevenson

2009

30-min indoor rowing

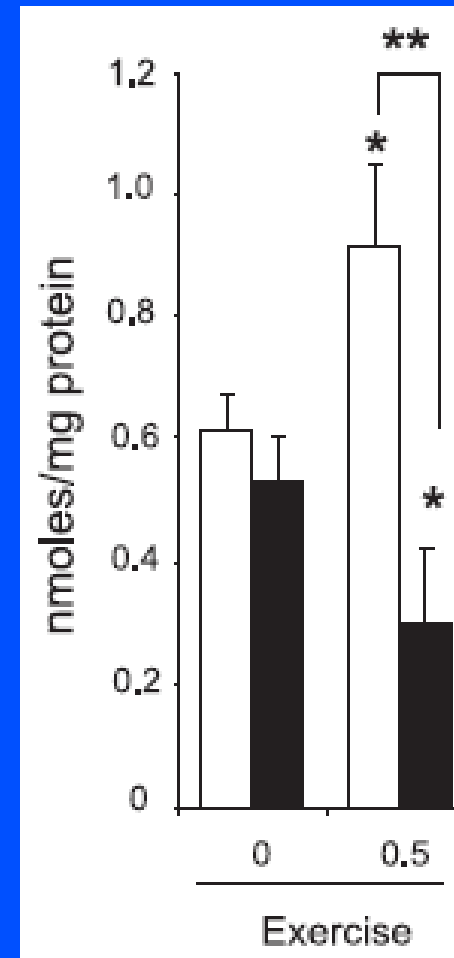
5 males

5 females

age:  $48 \pm 3$  yr



120 mg anthocyanins before exercise

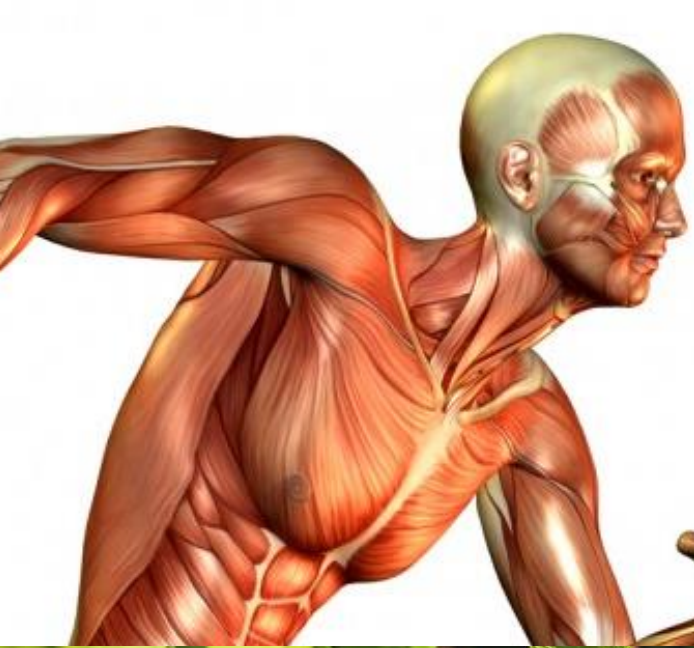


↓ exercise-induced oxidative stress

↓ protein carbonyls

■ blackcurrant





# Anthocyanin-Rich Supplementation: Emerging Potential for Sport and Exercise Nutrition

## Outline



## Anthocyanin-Rich Blackcurrant

↑ **blood flow**

Eur J Appl Physiol (2009) 98: 36–45  
DOI 10.1007/s00421-008-1279-y

**ORIGINAL ARTICLE**

Hitoshi Matsumoto · Eri Takenami  
Keiko Inanishi-Kurashige · Takaya Osada  
Toshihiro Katsumura · Takafumi Hamada

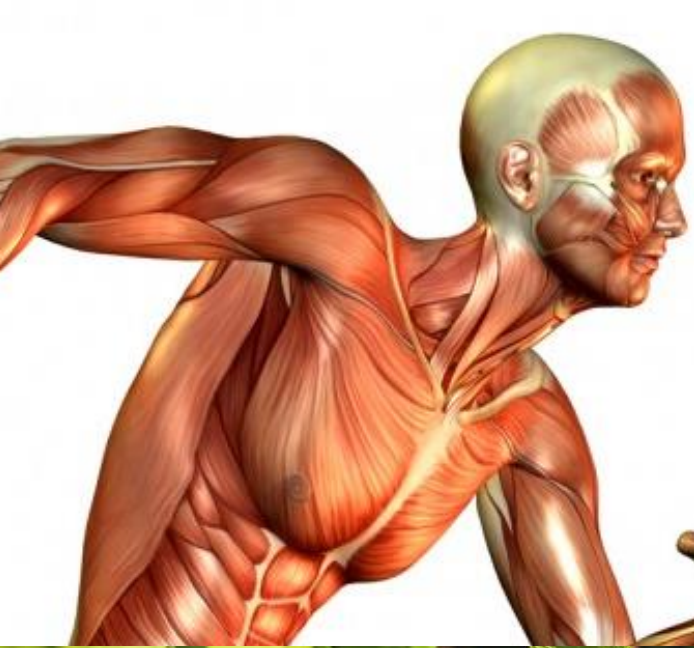
**Effects of blackcurrant anthocyanin intake on peripheral muscle circulation during typing work in humans**

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Health & Food Group, The New Zealand Institute for Plant and Food Research Ltd., Hamilton, New Zealand



# Anthocyanin-Rich Supplementation: Emerging Potential for Sport and Exercise Nutrition

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- Exercise performance and metabolic effects by anthocyanin intake



↑ **blood flow**

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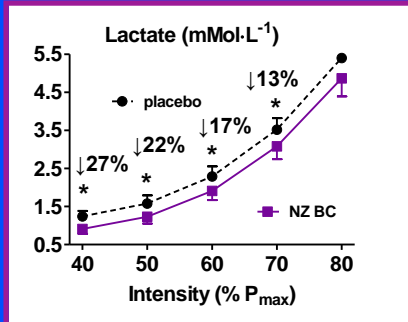
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Health & Food Group, The New Zealand Institute for Plant and Food Research, Ltd., Hamilton, New Zealand



**> 35 studies**



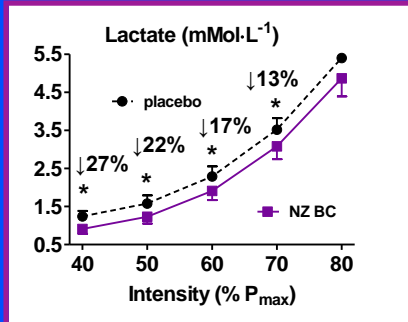




6 gram powder (~110 mg anthocyanins) for 7 days

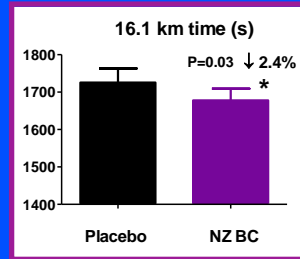
Willems et al. Int J Sport Nutr Exerc Metab 25, 367-374, 2015





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Willems et al. Int J Sport Nutr Exerc Metab 25, 367-374, 2015



cycling

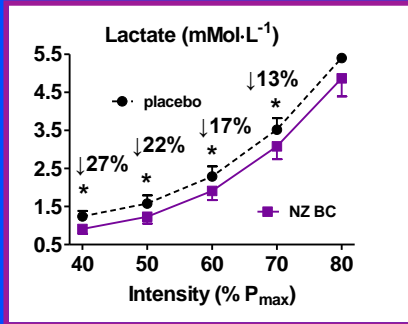


Cook et al. Eur J Appl Physiol 115, 2357-2365, 2015



1 per day for 7 days (~105 mg anthocyanins/day)



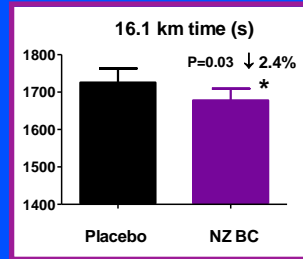


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## Acute Dietary Nitrate Supplementation Improves Cycling Time Trial Performance

Lansley et al., Med. Sci. Sports Exerc 43, 1125-1131, 2011



cycling



Cook et al. Eur J Appl Physiol 115, 2357-2365, 2015

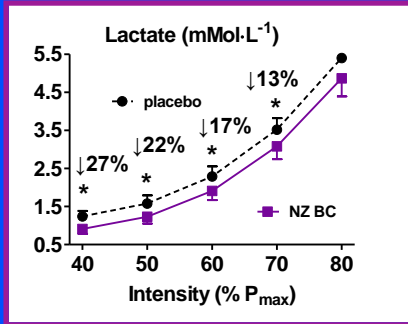


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16.1 km cycling ↓ 2.7%

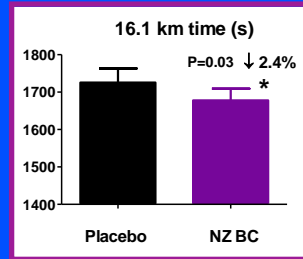






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16.1 km cycling ↓ 2.7%



Beetroot is a popular sports nutrition supplement



capsules



drinks



gels

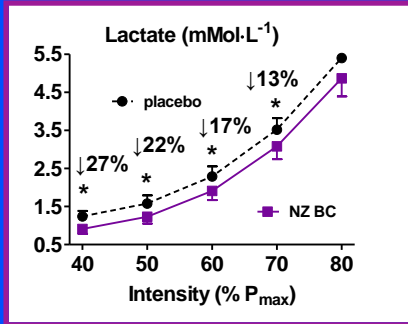


powder



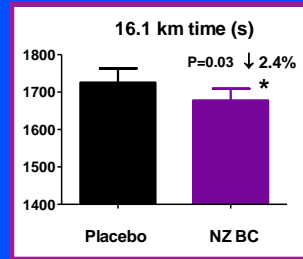
bars





6 gram powder (~110 mg anthocyanins) for 7 days

Willems et al. Int J Sport Nutr Exerc Metab 25, 367-374, 2015



cycling



Cook et al. Eur J Appl Physiol 115, 2357-2365, 2015



1 per day for 7 days (~105 mg anthocyanins/day)



2022

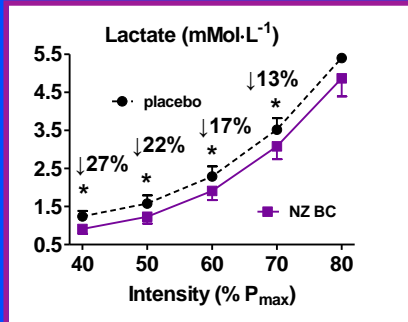
7 days (~150 mg anthocyanins/day)

5 km running ↓ 2%



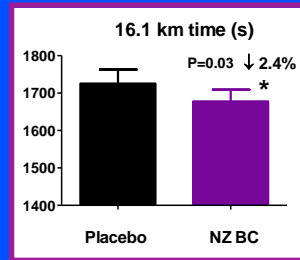
79% of anthocyanins is cyanidin-3-O-glucoside (five main anthocyanins)





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Willems et al. Int J Sport Nutr Exerc Metab 25, 367-374, 2015



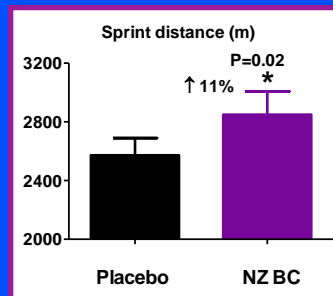
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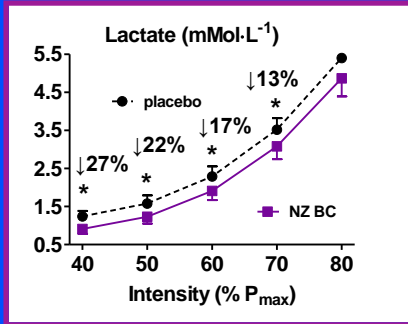
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Perkins et al., Int J Sport Nutr Exerc Metab 25(5), 487-493, 2015

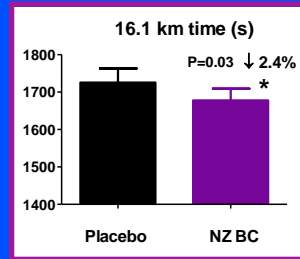






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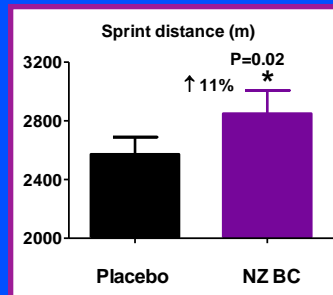
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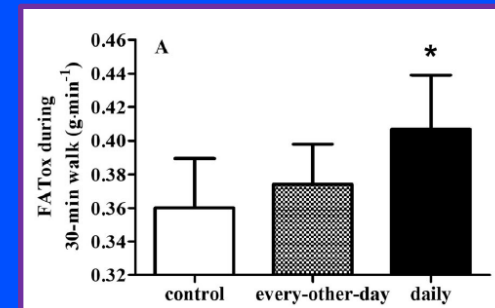
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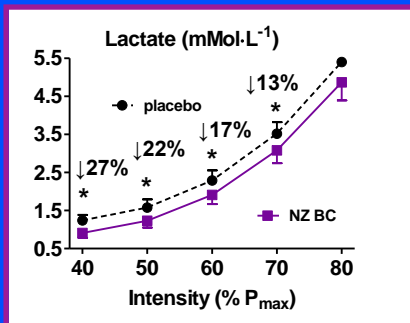


2 per day for 14 days (~210 mg anthocyanins/day)



Sahin et al. J Diet Suppl 19(1), 49-61, 2022





6 gram powder (~110 mg anthocyanins) for 7 days

Willems et al. *Int J Sport Nutr Exerc Metab* 25, 367-374, 2015

**nutrients** MDPI

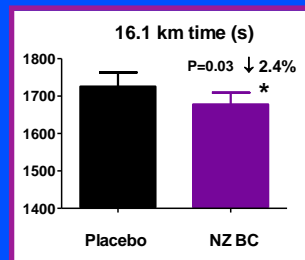
Article

### Effects of Wild Blueberries on Fat Oxidation Rates in Aerobically Trained Males

Kari D. Pilolla <sup>1</sup>, Jessie Armendariz <sup>2</sup>, Boe M. Burrus <sup>3</sup>, David S. Baston <sup>4</sup>, Karli A. McCarthy <sup>1</sup> and Taylor K. Bloedon <sup>2,\*</sup>

375 mg of anthocyanins for two weeks

>15 different anthocyanins

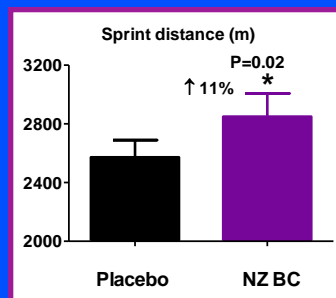


cycling

Cook et al. *Eur J Appl Physiol* 115, 2357-2365, 2015



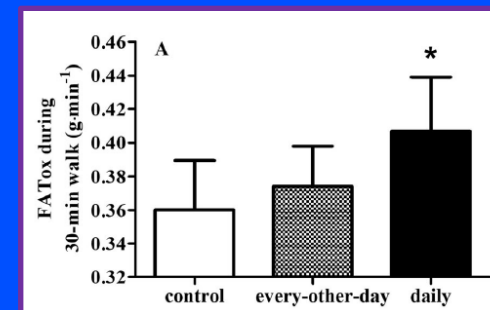
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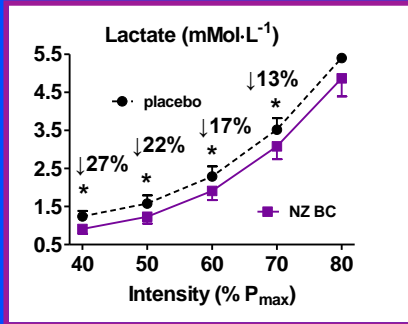


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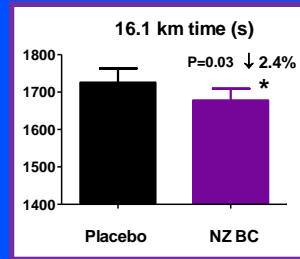
Şahin et al. *J Diet Suppl* 19(1), 49-61, 2022





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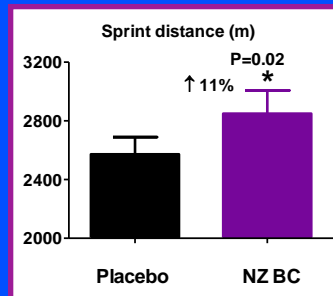


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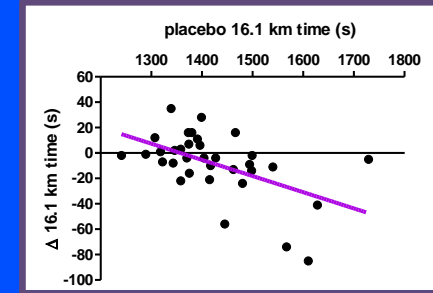
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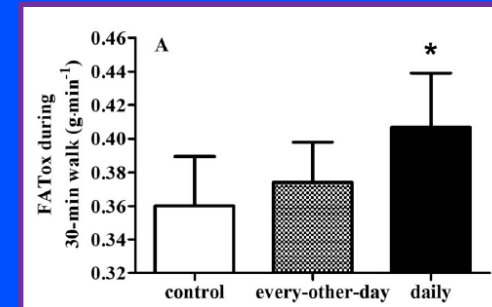
cycling



Montanari et al. Sports 11(5), 93, 2023  
acute intake (~315 mg anthocyanins)



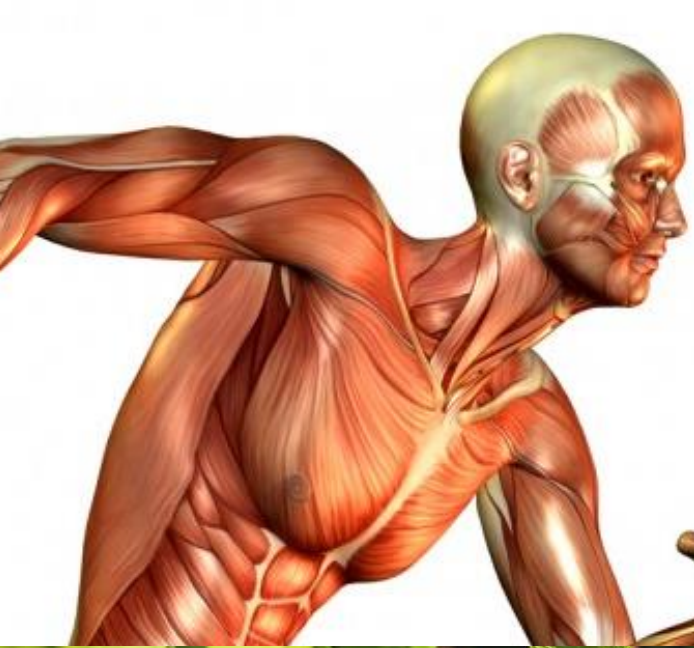
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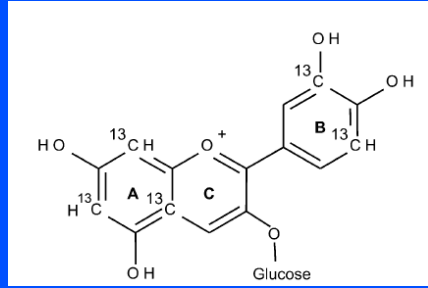
# Anthocyanin-Rich Supplementation: Emerging Potential for Sport and Exercise Nutrition

## Outline



- Future directions: We are not there yet?





**Cyanidin-3-glucoside**



**BJP** British Journal of  
Pharmacology

**2014**

## RESEARCH PAPER

# The pharmacokinetics of anthocyanins and their metabolites in humans

R M de Ferrars<sup>1\*</sup>, C Czank<sup>1\*†</sup>, Q Zhang<sup>2</sup>, N P Botting<sup>2‡</sup>, P A Kroon<sup>3</sup>,  
A Cassidy<sup>1</sup> and C D Kay<sup>1</sup>

### Parent anthocyanins

Cyanidin-3-glucoside

### Degradants

Protocatechuic acid (PCA)

Phloroglucinaldehyde

### Protocatechuic acid derived

Benzoic acid-4-glucuronide

Methyl-3,4-dihydroxybenzoate

PCA-3-glucuronide

PCA-4-glucuronide

PCA-sulfates<sup>c</sup>

Vanillic acid (VA)

IsoVA

VA-4-glucuronide

IsoVA-3-glucuronide

VA-sulfates<sup>c</sup>

4-Hydroxybenzaldehyde

Ferulic acid

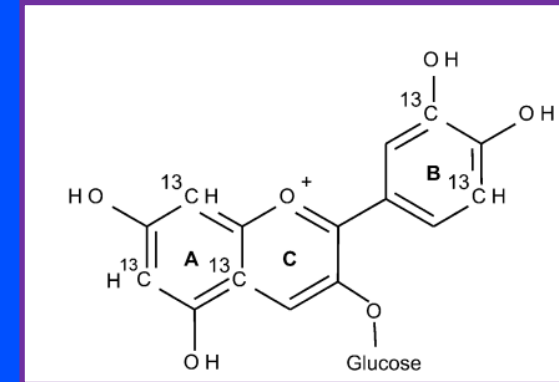
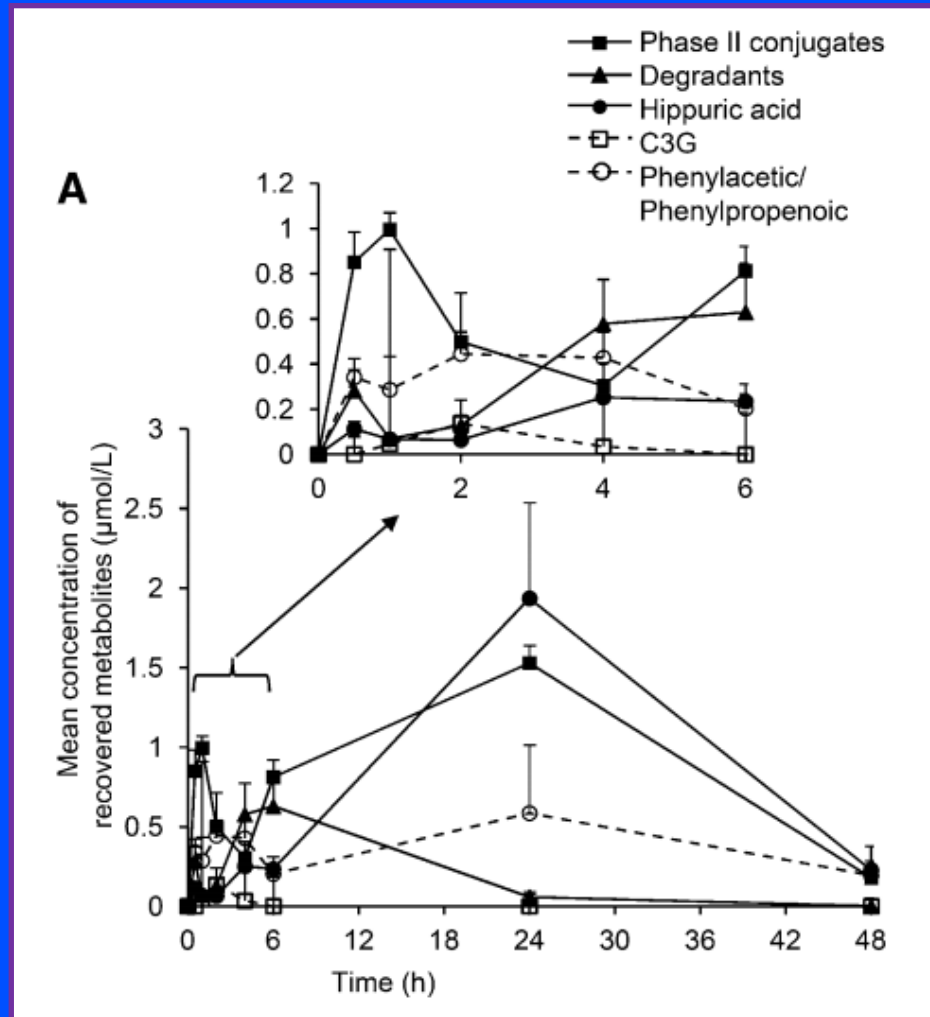
Hippuric acid

### Phloroglucinaldehyde derived

Ferulic acid<sup>d</sup>

**16 metabolites  
in blood**

# Human metabolism and elimination of the anthocyanin, cyanidin-3-glucoside: a $^{13}\text{C}$ -tracer study<sup>1-3</sup>



500 mg labelled cyanidin-3-glucoside

recovery  
 $43.9 \pm 25.9\%$   
 (range: 15.1%-99.3%)



Responders / Non-responders?

Concentration of identified metabolites in whole serum



**Delphinidin-3-glucoside**  
**Delphinidin-3-rutinoside**  
**Cyanidin-3-rutinoside**  
**Cyanidin-3-glucoside**



**New Zealand  
blackcurrant  
extract**

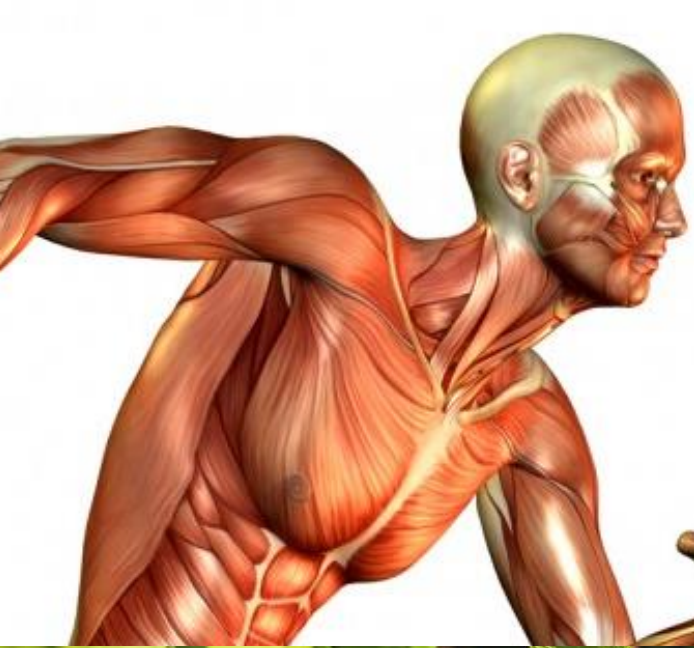


**gut microbiota?**  
**responders / non-responders?**

Parent anthocyanins
Cyanidin-3-glucoside
Degradants
Phloroglucinaldehyde
catechuic acid derived
Benzoic acid-4-glucuronide
Methyl-3,4-dihydroxybenzoic acid
PCA-3-glucuronide
PCA-4-glucuronide
PCA-sulfates <sup>c</sup>
Vanillic acid
IsoVA
VA-4-glucuronide
IsoVA-3-glucuronide
VA-sulfates <sup>c</sup>
4-Hydroxybenzoic acid
Ferulic acid
Hippuric acid
Phloroglucinaldehyde derived
Ferulic acid <sup>d</sup>



**cell/tissue function?**



# Anthocyanin-Rich Supplementation: Emerging Potential for Sport and Exercise Nutrition

## Outline



**MOVING IN THE RIGHT DIRECTION**

- Future directions: We are not there yet?



# Australian Institute of Sport



- **caffeine**
- **sodium bicarbonate**
- **creatine**
- **beta-alanine**
- **nitrate/beetroot juice**



**Supplements**  
Benefits and risks of using supplements and sports foods

**The AIS Sports Supplement Framework**  
Sports foods and supplements can play a small but important role in the sports nutrition plans of high performance athletes. Sporting organisations, sports science and medicine practitioners, coaches and athletes all contribute to a pragmatic and transparent approach that balances the pros and cons of supplement/sports food use by considering: is it safe? is it effective? is it permitted for use in sport?

The ABCD Classification system ranks sports foods and supplement ingredients into four groups according to scientific evidence and other practical considerations that determine whether a product is safe, permitted and effective in improving sports performance.

AIS Supplements Framework Committee has revised the Supplements Framework to ensure it has the most up to date information and resources for practitioners and athletes.

**Guiding principles for AIS Sports Supplements Framework**  
? Is it safe?  
? Is it permitted in sport?  
? Is there evidence that it "works"?

**AIS Position Statement: Supplements and Sports Foods in High Performance Sport** [PDF]

**A**  
GROUP A

**B**  
GROUP B

**C**  
GROUP C

**D**  
GROUP D



# Australian Institute of Sport



## Group B



### Evidence level:

Emerging scientific support, deserving of further research.

Considered for use by athletes under a research protocol or case-managed monitoring situation



### Use within Supplement Programs:

Considered for use by identified individual athletes within research or clinical monitoring situations.

**Note:** some of the products currently listed in Group B have been included due to their historic interest by Key Stakeholders.

The list in this group is identified as “examples” to note and may not be complete.



## Food Polyphenols



Food compounds which may have bioactivity including antioxidant and anti-inflammatory properties. May be consumed in food forms (whole or concentrate) or as isolated extracts.




### Fruit Derived Polyphenols


# Australian Institute of Sport 2021



## Group B



**Evidence**  
Emerging s  
Considered



**Use within**  
Considered  
**Note:** some

The list in this group is ide

### Food Polyph

Food compo  
properties. N

 **Fruit Derived Po**

## Fruit Derived Polyphenols


[Cherries **Berries, Blackcurrants** and Pomegranate]

Polyphenols are a class of organic compounds primarily found in plants that can be classified into four main families: lignans, phenolic acids, stilbenes and flavonoids.



Practitioner Fact Sheet 



Athlete Infographic 

*Athlete infographics have been developed for the information of athletes under the direct guidance of a sports dietitian. Sports dietitians have expert knowledge of sports supplements and their potential application in an athletes broader health and performance nutrition strategies. Always engage with a sports dietitian when considering the use of any supplement. <https://www.sportsdietitians.com.au/#find-sports-dietitian>*

# Future directions



still quite a journey!



exercise



recovery

- **The anthocyanin composition: Does it matter in humans?**



C57BL/6 mouse model of polygenic obesity



- **Optimal anthocyanin dosing strategies: Dose and intake duration**
- **Synergistic effects of anthocyanin and other supplements**



# Take home message

**Intake of anthocyanin-rich New Zealand blackcurrant has enriched the world of sport and exercise nutrition and shown the potential for anthocyanin supplementation**



# Acknowledgements

**Tokai University, Japan**  
**Prof Yoshika Sekine**



**Nippon Sport Science University, Japan**  
**Dr Takanobu Okamoto**  
**Dr Koicho Nakazata**



**University of Worcester, UK**  
**Dr Matthew Cook**



**University of Gloucestershire**  
**Dr Simon Fryer**



**University of Chichester, UK**  
**Dr Mandy Gault, Dr Sam Blacker, Prof Stephen Myers, Dr Ben Lee, Dr Chris Hodgson, Dr Julia Potter, Dr Ella Walker, Ian Perkins, Dr Akif Sahin, Dr Rianne Costello, Dr Stefano Montanari**



**Mahidol University, Thailand**  
**Dr Amornpan Ajjimaporn**  
**Dr Waree Widjaja**



**Northumbria University, UK**  
**Dr Karen Keane**



**Liverpool John Moores University, UK**  
**Dr Juliette Strauss**  
**Dr Sam Shepherd**



**High Point University, USA**  
**Dr Matthew Kuennen**



**BSc and MSc students, Jose Dos Santos Silva, Luke Cousins, David Williams, Sarah Vine, Connor Murphy, Charlie Godwin, Victoria Edwards, Lucy Wheeler, Daisy Smale, Daniel Norris, Amber Kelbie, Aaron Dunne, Samuel Barr**



**Health Currancy LTD**

**BE YOUR PERSONAL BEST**

**CurraNz**



**SUJON BERRYFRUITS**

**NEW ZEALAND INC.**  
**Blackcurrants**



**Thank you**

**Collaborations are welcomed**  
**m.willems@chi.ac.uk**



**July 21, 2023**

**Mark Willems**  
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