**Institution: University of Chichester**

**Unit of Assessment: Sport and Exercise Sciences, Leisure and Tourism**

**Title: Uptake of beta-alanine supplementation by the global sports nutrition industry**

## 1. Summary of the impact

Pioneering research at the University of Chichester lead by Professor Harris provided in 2006 first evidence on the effectiveness of beta-alanine supplementation in augmenting carnosine content in human skeletal muscle. Subsequent studies demonstrated the performance-enhancing effect of beta-alanine supplementation, particularly in high-intensity exercise. The research was exploited by a US company through a number of worldwide patents based on Harris' work achieving sales and license revenues of $4.8M in 2013 fiscal year alone. Beta-alanine supplementation has emerged as a legal means to enhance performance taken up at amateur and elite level sport worldwide; it is having global impact on the sports nutrition industry.

## 2. Underpinning research

The work on the effect of beta-alanine supplementation on muscle carnosine content and exercise performance was initiated in 2004 at the University of Chichester by Professor Harris and co-workers. Demonstration of the effectiveness of beta-alanine supplementation on carnosine content of skeletal muscle required analysis of muscle biopsy samples with high-performance liquid chromatography (Harris et al., 2006). In this landmark study (i.e. Harris et al., 2006), the time-course response of blood plasma concentrations of beta-alanine and the effects of chronic beta-alanine supplementation on muscle carnosine over a four week period with different amounts of beta-alanine intake were investigated. As such, the optimal dose of beta-alanine supplementation was established by this study and became, in part through collaborative endeavour, the adopted beta-alanine supplementation protocol by UK (Nottingham Trent University) and non-UK based research groups (e.g. University of Oklahoma, USA; University of São Paulo, Brasil; Ghent University, Belgium). Subsequent work, directed by Harris (Hill et al., 2007) confirmed an effect on high intensity cycling performance by 4 week of beta-alanine supplementation. Hill et al (2007) also examined the effect of beta-alanine supplementation over a 10 week period and showed that a larger increase in carnosine content in both slow- and fast-twitch muscle fibres was associated with increased high-intensity cycling performance. This was the first study (Hill et al., 2007) that established the impact of augmented carnosine content on high-intensity exercise. Further studies by Harris and co-workers (Kendrick et al., 2008, 2009) found 1). no evidence that a combination of isokinetic training and beta-alanine supplementation for 4 weeks would result in higher carnosine content, and 2). that 10 weeks of resistance training did enhance carnosine content, underpinning the view that the beta-alanine supplementation is key for augmenting carnosine content. Since leaving Chichester, co-worker Sale continued to build on the landmark studies undertaken at Chichester. For example, work on the effect of beta-alanine supplementation for high-intensity cycling capacity (Sale et al., 2011), endurance of sustained isometric contractions of knee extensors (Sale et al., 2012), high-intensity swimming performance (De Salles Painelli et al., 2013), high-intensity intermittent upper-body performance in judo and jiu-jitsu competitors (Tobias et al., 2013) and 2000m rowing performance (Hobson et al., 2013). Although the main focus of Harris and co-workers was initially on the ergogenic effects on sport performance, they were able to show elevated carnosine content in resistance-trained body builders (Tallon et al., 2005), and lower carnosine content in older subjects (Tallon et al., 2007). Subsequent work in older subjects showed effects of beta-alanine supplementation on performance with potential implications for activities of daily living and prevention of falls (Stout et al., 2008). A review by the British Journal of Sports Medicine (co-authored by Harris), in a prominent series on nutritional supplements, covered beta-alanine as a performance enhancing aid (Castell et al., 2010).

## 3. References to the research


- **Harris** RC, Tallon MJ, Dunnett M, Boobis L, Coakley J, Kim HJ, Fallowfield JL, Hill CA, Sale C, Wise JA. The absorption of orally supplied beta-alanine and its effect on muscle carnosine synthesis in human vastus lateralis. **Amino Acids** 30(3):279-289, 2006. doi:10.1007/s00726-006-0299-9. [185 citations (Google Scholar: 20/11/2013), JIF (2012): 3.914].
- Hill CA, **Harris** RC, Kim HJ, Harris BD, Sale C, Boobis LH, Kim CK, Wise JA. Influence of beta-alanine supplementation on skeletal muscle carnosine concentrations and high intensity cycling

capacity. **Amino Acids** 32(2): 225-233, 2007. doi: 10.1007/s00726-006-0364-4 [209 citations (Google Scholar: 20/11/2013), JIF (2012): 3.914].

- Kendrick IP, **Harris** RC, Kim HJ, Kim CK, Dang VH, Lam TQ, Bui TT, Smith M, Wise JA. The effects of 10 weeks of resistance training combined with beta-alanine supplementation on whole body strength, force production, muscular endurance and body composition. **Amino Acids** 34(4):547-54, 2008. doi: 10.1007/s00726-007-0008-3 [83 citations (Google Scholar: 20/11/2013), JIF (2012): 3.914].
- Kendrick IP, Kim HJ, **Harris** RC, Kim CK, Dang VH, Lam TQ, Bui TT, Wise JA. The effect of 4 weeks beta-alanine supplementation and isokinetic training on carnosine concentrations in type I and II human skeletal muscle fibres. **European Journal of Applied Physiology** 106(1):131-8, 2009. doi: 10.1007/s00421-009-0998-5 [33 citations (Google Scholar: 20/11/2013), JIF (2012): 2.660].
- Stout JR, Graves BS, Smith AE, Hartman MJ, Cramer JT, Beck TW, **Harris** RC. The effect of beta-alanine supplementation on neuromuscular fatigue in elderly (55-92 Years): a double-blind randomized study. **Journal of the International Society of Sports Nutrition** 5:21, 2008. doi: 10.1186/1550-2783-5-21 [42 citations (Google Scholar: 20/11/2013), JIF (30/09/2013): 1.83].
- Sale C, Saunders B, **Harris** RC. Effect of beta-alanine supplementation on muscle carnosine concentrations and exercise performance. **Amino Acids** 39(2):321-33, 2010. doi: 10.1007/s00726-009-0443-4. [58 citations (Google Scholar: 20/11/2013), JIF (2012): 3.914].

Total # citations (20/11/2013): 610.
Prof. Roger Harris was employed at the University from 1/11/1998 to 1/5/2009.

## 4. Details of the impact

All the work by Professor Harris was supported by Natural Alternatives International (NAI) Inc, an American based company and leading formulator, manufacturer and marketer of customized nutritional supplements whose published strategy is to "*commercialize our beta-alanine patent estate through contract manufacturing, royalty and license agreements and protect our proprietary rights*". NAI have filed and been granted filed patents worldwide (US, EU, China, Canada, Japan) based on Harris' beta-alanine work to create the '*beta-alanine patent estate*' (see http://www.carnosyn.com/about). In particular, Harris' discovery that the presence of paraesthesia (tingling sensation in the skin) occurred with beta-alanine supplemented in bolus form, led to the development and manufacture of slow-release beta-alanine capsules by NAI, these capsules minimizing or preventing paraesthesia effects. Thus in 2012, the slow-release beta-alanine capsules were patented by NAI under the CarnoSyn® registered trademark (U.S. Patent No. 8,129,422 entitled "Methods and compositions for increasing the anaerobic working capacity in tissues."). Harris is named as one of the two inventors on this patent (other NAI patents also name Harris as sole or joint inventor) which cites more than 30 of Harris' publications within the period he was employed at Chichester (including all of those listed under section 3). Furthermore, during fiscal year 2011, NAI expanded the beta-alanine licensing programs through the execution of a supply agreement with Nestle Nutrition (Nestle) and a license and supply agreement with Abbott Laboratories (Abbott). From the start of fiscal year 2009, NAI revenues with the sale and licences of beta-alanine has grown from $515.000 to $4.8 million in the fiscal year 2013. During fiscal year 2013, NAI issued seven new beta-alanine patents also based on Harris' work whilst at Chichester bringing the number of NAI patents possessed by June 2013 to twenty-five for beta-alanine and five for sustained released beta-alanine. Multiple WO, US, CN and one KR filed patents returned from the WIPO Patentscope database that are beta-alanine related and cite Harris as the inventor; these patents also establish the deep connection between Roger Harris and NAI Inc.

Many sports nutrition companies (e.g. UK-based Maximuscle, the leading European Sports Nutrition company, bought by GlaxoSmithKline for £162 million), now provide beta-alanine as a single ingredient or incorporated in a multi-ingredient product. Elite athletes use Maximuscle beta-alanine (e.g. Welsh National Rugby Union ("beta-alanine is used 4 weeks prior to and for duration of campaigns") and British Weight Lifting). It is quite rare for elite athletes to share 'secrets' during interview about their nutritional intake, however, Dai Green, a 400 m hurdles World Champion acknowledged taking beta-alanine. One can only speculate about the impact of such revelation by a World Champion. Confirmation of the reach and significance of Harris' work comes through the Australian Institute of Sport (AIS) Sports Supplement Program in its 2012 factsheet on beta-alanine

supplementation. This factsheet targets to inform elite and amateur athletes, their coaches and support organisations and arises from "*a cutting-edge program initiated in 2000 following a major review of supplement practices by AIS athletes and their related issues [it] is designed to provide world's best practice in the research, education and provision of sports foods and supplements for AIS athletes and coaches*".

Professor Harris has been an advocate for evidence based sports nutrition for many years. Harris and co-workers were invited to contribute to the BBC TV series called "The Truth about Food" and was screened on BBC2 in February 2007. He received the Lifetime Achievement Award from the International Society of Sports Nutrition in 2011 for outstanding contributions to the sciences of sports nutrition. He routinely contributes to public and scientific debate, for example, evidence on beta-alanine supplementation was presented by Harris at the 76th Nestlé Nutrition Institute at its scientific workshop in Oxford (UK) on 15 August 2012 during the London Olympic Games, a workshop in which a multidisciplinary group of scientists, athletes, and coaches discussed the latest scientific evidence on the effectiveness of micronutrients and exercise performance. Nestlé Nutrition Institute has 180,000 registered users and "*shares leading science-based information and education with health professionals, scientists and nutrition communities and stakeholders*". The lecture by Professor Harris on the "Ergogenic properties of beta-alanine" is freely available on-line (http://www.nestlenutrition-institute.org).

## 5. Sources to corroborate the impact

- Natural Alternatives International, Inc. Annual report for the fiscal year ended June 2013. http://www.nai-online.com/investor_relations.php
- Natural Alternatives International, Inc. Announces Issuance of New U.S. Patent Covering CarnoSyn(R) Beta-alanine. http://www.nai-online.com/content/?q=node/36
- U.S. Patent No. 8,129,422 entitled "Methods and compositions for increasing the anaerobic working capacity in tissues http://www.google.com/patents/US8129422; this patent was also published as CA2621365A1, CA2621365C, CN101309688A, EP1883406A2, EP1883406A4, US8329207, US8394402, US20090220575, US20130030052, US20130142859, WO2007073398A2, WO2007073398A3 and extends worldwide.
- http://patentscope.wipo.int/search/en/result.jsf?currentNavigationRow=next&prevCurrentNavigationRow=1&query=FP: Beta alanine ALLNAMES: Natural Alternatives International&office=&sortOption=Pub Date Desc&prevFilter=&maxRec=14
- All other patents filed and granted to Roger Harris as the inventor can be accessed here: https://www.google.com/search?tbo=p&tbm=pts&hl=en&q=ininventor:%22Roger+Harris%22
- Prof Harris link with NAI intellectual property. http://www.carnosyn.com/news/natural-alternatives-international-inc-announces-new-sustained-release-beta-alanine-intellectual-property.
- Nutrition Business Journal – strategic information for the nutrition industry. http://newhope360.com/site-files/newhope360.com/files/uploads/2013/04/TOCSNWLREPORT%20FINAL.pdf.
- Australian Institute of Sport. Fact Sheet was prepared by AIS Sports Nutrition as part of the AIS Sports Supplement Program (2011) quote: "*The current interest in β-alanine was initiated by research by Professor Roger Harris and colleagues (University of Chichester, UK)*". (http://www.ausport.gov.au/__data/assets/pdf_file/0006/446721/B-alanine_11-_Website_fact_sheet.pdf)
- http://www.bbc.co.uk/sn/humanbody/truthaboutfood/best/martialveggies.shtml
- Interview with 400 m hurdles World Champion. http://www.run247.com/articles/article-2552-interview-with-world-400m-hurdles-champion-dai-greene.html