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# POSITIONING RESEARCH AND SCHOLARLY INNOVATION WITHIN A "TRANSDISCIPLINARY" APPROACH: THE CASE OF THE SOUTH AFRICAN INDIGENOUS PLANT ROOIBOS (*ASPALATHUS LINEARIS*) AND ITS POTENTIAL AS AN ERGOGENIC AID

*Posicionando a pesquisa e a inovação acadêmica em uma abordagem "transdisciplinar": o caso da planta indígena Sul-Africana Rooibos (Aspalathus linearis) e seu potencial como auxiliar ergogênico*

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## ABSTRACT

Based on the shared expertise of two research entities at the Cape Peninsula University of Technology (CPUT) a transdisciplinary (TD) research approach was adopted to investigate whether Rooibos an indigenous South African plant with its unique bioactive compounds modulates oxidative stress and potentially acts as an ergogenic supplement. Due to the nature of this unique biotechnology and sport business collaboration along with support from the South African Rooibos Council (SARC) and associated academic stakeholders, various beneficial outcomes were anticipated, including: 1) to provide scientific findings informed by the innovative technologies that measure metabolic and gene-diet interaction responses to phenolic-rich Rooibos; 2) to assess the potential of Rooibos to modulate oxidative stress during exercise and underscore its anticipated ergogenic properties; 3) to utilize scientifically derived evidence to beneficiate Rooibos in the lucrative sport supplement market; 4) to provide rationale to optimize the equitable sharing of benefits derived from Rooibos to the relevant indigenous communities, and 5) to enhance sustainable economic benefits derived from various policy enactments including the Protected Designation of Origin (PDO) status. The findings from two randomized double-blinded placebo controlled intervention trials provide a strong indication that the unique bioactive compounds of Rooibos may have benefits for exercise performance and recovery and as a potential ergogenic supplement, which may have further positive ramifications for the Rooibos value chain in terms of beneficiating Rooibos. Additionally, the TD approach has acknowledged the importance of indigenous biological resources, and the commitment to share sustainable economic benefits with traditional knowledge holders in a fair and equitable way.

**Keywords:** Transdisciplinary, Ergogenic, Rooibos, Sustainability.

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# POSICIONANDO A PESQUISA E A INOVAÇÃO ESCOLAR DENTRO DE UMA ABORDAGEM "TRANSDISCIPLINAR": O CASO DA PLANTA INDÍGINA SUL-AFRICANA ROOIBOS (ASPALATHUS LINEARIS) E SEU POTENCIAL COMO ERGOGÊNICO

*Positioning research and scholarly innovation within a "transdisciplinary" approach: the case of the South African indigenous plant Rooibos (Aspalathus linearis) and its potential as an ergogenic aid*

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**RESUMO**

Com base na experiência compartilhada de duas entidades de pesquisa na Universidade de Tecnologia da Península do Cabo (CPUT), uma abordagem de pesquisa transdisciplinar (TD) foi adotada para investigar se o Rooibos, uma planta indígena sul-africana com seus compostos bioativos exclusivos, modula o estresse oxidativo e potencialmente atua como um suplemento ergogênico. Devido à natureza dessa colaboração exclusiva de biotecnologia e negócios esportivos, juntamente com o apoio do South African Rooibos Council (SARC) e partes interessadas acadêmicas associadas, vários resultados benéficos foram antecipados, incluindo: 1) fornecer descobertas científicas informadas pelas tecnologias inovadoras que medem as respostas metabólicas e de interação gene-dieta aos Rooibos ricos em fenólicos; 2) avaliar o potencial do Rooibos para modular o estresse oxidativo durante o exercício e enfatizar suas propriedades ergogênicas antecipadas; 3) utilizar evidências cientificamente derivadas para beneficiar Rooibos no lucrativo mercado de suplementos esportivos; 4) fornecer justificativa para otimizar o compartilhamento equitativo dos benefícios derivados do Rooibos para as comunidades indígenas relevantes e 5) para aumentar os benefícios econômicos sustentáveis derivados de várias promulgações de políticas, incluindo o status de Denominação de Origem Protegida (DOP). As descobertas de dois estudos randomizados duplo-cegos de intervenção controlados por placebo fornecem uma forte indicação de que os compostos bioativos exclusivos do Rooibos podem trazer benefícios para o desempenho e recuperação do exercício e como um potencial suplemento ergogênico, que pode ter ramificações positivas adicionais para a cadeia de valor do Rooibos em termos de beneficiamento do Rooibos. Além disso, a abordagem TD reconheceu a importância dos recursos biológicos indígenas e o compromisso de compartilhar os benefícios econômicos sustentáveis com os detentores do conhecimento tradicional de maneira justa e equitativa.

**Palavras-chave:** Transdisciplinar, Ergogênico, Rooibos, Sustentável.

## INTRODUCTION

This paper is considered within the South African context, which is characterized by the prevalent conditions of poverty, underdevelopment, legacies of colonialism and the systemic consequences of legislative discrimination in favor of white people under the National Party government during the period 1948–1994, commonly known as apartheid (Walton & Engelbrecht, 2022).

It is worrisome that a report by Amnesty International details the repeated failure of the elected government since 1994 to address these issues of poverty and underdevelopment, which is not only a question of accountability, but also has consequences for the future of South Africa (Amnesty International, 2020). The perpetuation of such historically rooted problems in contemporary South Africa has meant that persistent issues of inequality prevail in the education system, impacting on the inclusion of traditionally marginalized racial groups to conduct research and innovation, especially at universities. As noted by Engelbrecht (2006:254) "[t]he central feature which distinguishes South Africa from other countries in terms of education provision, is the extent to which racially entrenched attitudes and the institutionalization of discriminatory practices led to extreme disparities in the delivery of education, a reflection of the fragmentation and inequality that characterized society as a whole".

It therefore needs to be acknowledged that educational and research endeavor in South Africa's higher education system is challenging for both individuals and institutions that were historically marginalized and the reality is that to a significant extent these debilitating socio-economic issues persist. The present paper relates to the positioning of a research project within a "transdisciplinary" (TD) approach at such an institution and the application of innovative metabolomic and genomic research techniques that have and are creating new areas of knowledge e.g "sportomics" combining sport science with metabolomics and "kinesiogenomics" combining kinesiology, the scientific study of human movement and genomics (Bongiovanni et al., 2022; Ginevičienė et al., 2022; Wackerhage et al., 2009). As Bijl-Brouwer and colleagues noted complex societal challenges cannot be resolved with quick fixes, nor can they be successfully addressed from disciplinary or institutional silos. They propose an innovative approach to tackling contemporary societal challenges such as the contextual circumstances that prevail in South Africa, which are based on complexity theory and transdisciplinarity. Therefore by adopting transdisciplinary approaches enables not only innovation but also helps us understand how different perspectives and ways of knowing held by relevant actors can be combined to serve effective action in complex contexts (Van der Bijl-Brouwer et al., 2021).

Whilst the paper pivots largely around the scientific and clinical investigations into the efficacy of Rooibos as a potential ergogenic; it is also useful to note that the study has sought to include community-based education approaches, because these acknowledge real-world problems such as the unique socio-economic issues associated with inequality in South Africa, as well as the goals of sustainability science as a transformational scientific field.

In particular, this paper seeks to highlight the benefits of collaboration and support from a diverse group of stakeholders that relates to an ongoing study into the South African indigenous plant Rooibos (Aspalathus linearis), which is high in antioxidant activity and bioactive phytochemicals (Marnewick, 2009). The TD approach allows for shared conceptual frameworks that in turn facilitate collaborative decision making through the entire learning process, from problem identification all the way through to viable solution discovery (Smythe, 2017). This point is mentioned to highlight the need (and responsibility) of the role players involved in the study to not only conduct ethically sound experimental research with a relevant purpose, but importantly to factor in and understand the correspondingly important economic and social implications for the communities involved in the Rooibos value chain, especially an acknowledgment of indigenous knowledge (IK) systems and the policy enactments that prioritize the equitable sharing of benefits arising out of indigenous biological resources. It was therefore implicit in the overall study design that inclusivity was a necessary precursor to promote active and positive engagement with all role players. Furthermore, a transdisciplinary approach is a vital factor to fulfill the sustainable development goals determined by the United Nations (Pennington et al., 2020). It has been argued that a TD paradigm can assist universities achieve their often-stated role as major driving forces of sustainable change by changing their central functions and the ways they interact with the world outside of classrooms and laboratories (Scott et al., 2012; Lozano, 2006).

The purpose of this particular TD project included not only an experimental research study, but also

incorporated various teaching and learning considerations. The key elements of the TD project can be summarized as follows:

1) Firstly, to provide scientific findings informed by the innovative technologies that measure metabolic and gene-diet interaction responses to phenolic-rich Rooibos;

2) Secondly, to assess the potential of Rooibos to modulate oxidative stress during exercise and underscore its anticipated ergogenic properties;

3) Thirdly, to utilise scientifically derived evidence to beneficiate Rooibos in the lucrative sport supplement market;

4) Fourthly, to provide a rationale to optimize the equitable sharing of benefits derived from Rooibos to the relevant indigenous communities;

5) Finally, to enhance sustainable economic benefits derived from various policy enactments including the Protected Designation of Origin (PDO) status.

It is argued the findings from this TD orientated research project provide scientifically validated findings that have the potential to substantiate the beneficiation of Rooibos in the lucrative sport supplement market and furthermore, provide further understanding and justification to shape policy development that supports economic and social sustainability in the Rooibos sector. However, as Deschepper et al. (2017) note there is still a lacuna to fill, with transdisciplinary studies bridging the social sciences and biomedical sciences. It becomes apparent therefore that the various anticipated outcomes of the study while founded on experimental scientific research designs also need to acknowledge the IK systems that foregrounded our contemporary understanding of the benefits of Rooibos. The responsibility here is for an inclusive appreciation of IK by all stakeholders in the Rooibos value chain, including the research teams. This is because these synergies will provide impetus for organizations and government agencies that are better enabled to develop and enact legislation that supports the fair and equitable sharing of benefits arising out of indigenous knowledge and indigenous biological resources via an inclusive approach to research and education.

The research described in this paper was framed within a transdisciplinary approach to advance learning. The paper seeks to be innovative in terms of acknowledging the intersection of related foundational disciplines, such as "indigenous knowledge", "indigenous plants", "traditional medicine" and "ethnobotany". However, the overall approach is built around the key axis, namely an experimental research project into whether Rooibos an indigenous South African plant with its unique bioactive compounds modulates oxidative stress and potentially acts as an ergogenic supplement. Whilst the study utilizes standard applied human physiological testing and biotechnology protocols it also informed the development of "omics", (e.g., genomics, transcriptomics, metabolomics, proteomics, and epigenomics), which are technologies that are pioneering new advances in medical technology and the development of ergogenic aids for enhancing physical exercise and recovery. These considerations further embrace sport and exercise applications, along with the economic deliberations that further inform business decision making and meaningful policy development. This paper seeks to espouse the view that transdisciplinary research involves the generation of new models that transcends what was possible within any singular discipline (Rosenfield, 1992). This perspective of transdisciplinarity is aligned with Piaget's wider usage of the term as a unity of knowledge beyond disciplinary boundaries (Piaget, 1972). Correspondingly, it is acknowledged that a transdisciplinary research approach is particularly suited to not only generate scientific knowledge, but also invent real-world solutions and to be innovative (Hölsgens et al., 2023).

## 1 LITERATURE REVIEW

### 1.1 Transdisciplinarity approaches to learning and research

The conventional structure of learning at institutions of higher education, such as universities and colleges is organised into academic disciplines, which in essence are sub-divisions of knowledge that characterise teaching and research. Daneshpour (2022) notes that the dominant approach in the current university and educational system continues to be based on this single-disciplinary style, while Fortuin & Van Koppen (2016) make the observation that various attempts and experiments have been conducted to shift education at these institutions towards interdisciplinary or transdisciplinary approaches in order to better meet real-world expectations. According to

Appel (2018) a transdisciplinary view (or "transdisciplinarity") is defined as practice and research efforts conducted by academics from different disciplines working jointly to create new conceptual, theoretical, methodological, and transnational innovations that integrate and move beyond discipline-specific approaches to address complex problems.

Interestingly the notion of TD is not necessarily new and Daneshpour (2022) believes that the history of the transdisciplinary model can be traced back to the year 1840, where the term "consilience" was used, which refers to a "jumping together of knowledge by linking facts across disciplines to develop a common explanation" (Glittenberg, 2004: 8). This process emerged in part due to the perceived demand for a more rigorous learning process by interweaving knowledge of humanity and natural science. Nonetheless, the first observation of the term, transdisciplinary, dates back to the year 1982 (Glittenberg, 2004). It appears that a significant elevation of the concept can be associated to a conference on interdisciplinarity in 1970, and a number of subsequent publications on a systems approach to education and innovation by Erich Jantsch and the epistemology of interdisciplinary relationships by Jean Piaget (Jantsch, 1970; Piaget, 1972). The differentiation and character of the basic five education and research approaches in terms of complexity and function are poignantly summarised by Nicolescu (2002) as follows:

*Intradisciplinary*: working within a single discipline (closed system).

*Cross disciplinary*: viewing one discipline from the perspective of another.

*Multidisciplinary*: people from different disciplines working together, each drawing on their disciplinary knowledge.

Interdisciplinary: integrating knowledge and methods from different disciplines, using a real synthesis of approaches—but still disciplinary.

*Transdisciplinary*: creating a unity of intellectual frameworks beyond the disciplinary perspectives. Creating new "transcendent" areas of knowledge and practice (dynamic—open system).

Nicolescu (1985) goes onto to emphasize that a special type of logic (mode of reasoning) is needed that focuses on two key aspects of transdisciplinary knowledge creation, namely:

(a) the complexity of the situation and

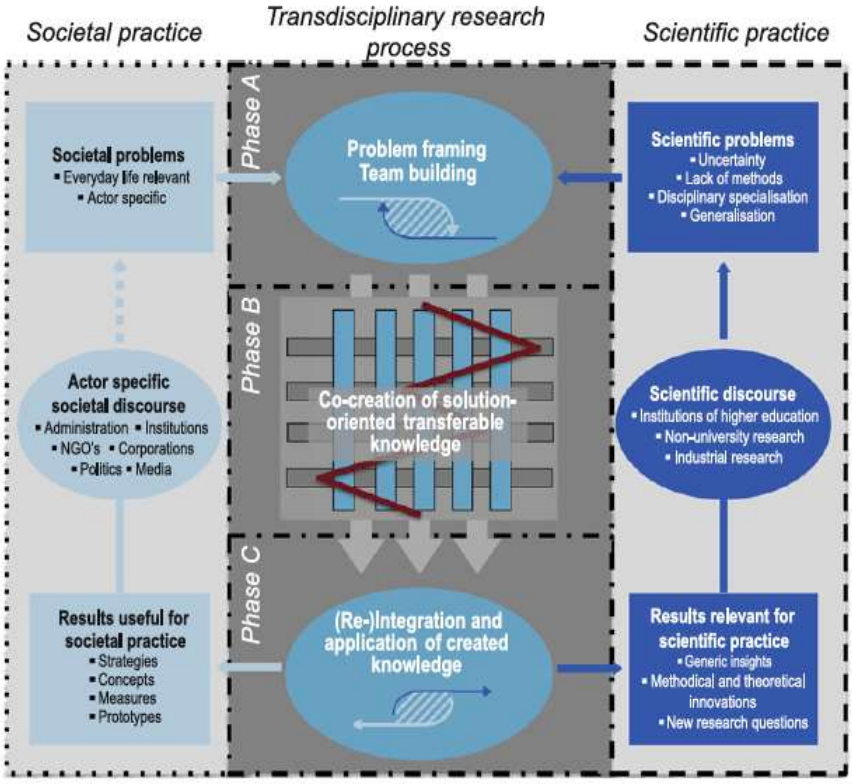
(b) the need to reconcile contradictory mindsets operating on different levels of Reality (e.g., anthropologists, engineers, businesses, bureaucrats, politicians, artists, social workers, and indigenous elders).

Given that TD is predicated toward resolving what Lawrence et al. (2022) refer to as the grand challenges and wicked problems of the Anthropocene, the same authors acknowledge that this will require skillfully combining a broad range of knowledge and understandings—both scientific and non-scientific—of Earth systems and human societies. It therefore follows that deep disagreements are likely to emerge due to historically embedded economic and social problems, as well as differences in often intransigent educational and research approaches that further impact on environmental and climate issues. The focus of this paper revolves around an evolving TD research project between two research entities at the Cape Peninsula University of Technology (CPUT) in Cape Town, South Africa, namely the Applied Microbial and Health Biotechnology Institute (AMHBI) with specialist researchers in the areas of Biocatalysis, Biomarkers, Biotechnology, Chemoprevention, Oxidative Stress, Proteomics and related research fields and the Centre for Sport Business and Technology Research (CSBTR) with specialist researchers in the areas of Sport and Exercise Science and Sport Business (management, marketing, branding etc.), along a number of other universities who have provided additional expertise and resources, as well as the South Africa Rooibos Council (SARC) whose principle mandate is to responsibly promote Rooibos and its attributes to the consumer and protects the interests of the Rooibos consumer and SARC stakeholders supported by effected research and communication. The importance of SARC in the overall shaping and support of research is demonstrated by the fact that SARC is a significant role player in the Rooibos value chain with its stakeholder membership providing an estimated 80% of the volume and value of the annual production and sales of Rooibos (SARC, 2023).

The researchers at the two entities developed a study based on the conceptual model proposed by Lang at al. (2012) (see Figure 1) of an idealized transdisciplinary research (TDR) process, which seeks to be inclusive and

community-based to meet both the requirements posed by real-world problems as well as the goals of sustainability science as a transformational scientific field.

**Figure – 1 Depiction of a conceptual model of an idealized transdisciplinary research (TDR) process**




Source: Adapted from Lang et al. (2012)

## 1.2 An "Omics" approach in teaching and learning

It is abundantly clear that with the elevation in levels of athletic and sporting performance that scientists are also developing and utilizing new and innovative techniques to facilitate these improvements. In the context of this paper it is the application of metabolomics, namely the comprehensive and quantitative analysis of all metabolites of the biological system under study (Fiehn, 2001). Thus, metabolomics is the study of end-products of intricate biochemical pathways (deriving from genome, transcriptome, and proteome metabolism) that occur within and outside the cell (Rinschen et al., 2019). The 'metabolome' is the method by which cells communicate, which can provide helpful contributions to the understanding of the complex interaction between genes and the environment. These networks of specific biological processes or physiological phenomena are activated upon a given stimulus/perturbation, such as disease, pharmaceutical drug, environment, diet, or physical activity (Bongiovanni et al., 2022).

Ginevičienė et al. (2022) have noted that sport and exercise scientists who study the adaptation of athletes to training and competition have started using a variety of physiological, biochemical and biomedical indicators including those techniques that elucidate the cellular and molecular responses to exercise that lead to adaptation at the whole-body level. In recent years, an increasing number of post-genomic analysis methods have been employed in the search for new markers in sports that can be used to quantify changes in the physiological and functional state of the human body (Bouchard et al., 2011; Tucker et al., 2012). Hasin et al. (2017) go on to describe metabolomics as a field that simultaneously quantifies multiple small molecule types, such as amino acids, fatty acids, carbohydrates, or other products of cellular metabolic functions.

The advances in high-throughput technologies now offer sport scientists the opportunity to apply "omics" (e.g., genomics, transcriptomics, metabolomics, proteomics, and epigenomics) approaches to examine the global

features of a cell, tissue, or organism during exercise and recovery. According to Tanaka et al. (2016) omics approaches are being applied with some success to a wide range of pertinent biomedical problems such as cancer diagnosis but also in sports science and sports medicine such as for the identification of biomarkers of trainability or blood doping.

It is not a surprise therefore that 'metabolomics' has evolved more specifically into 'sports genomics', which is the scientific discipline focusing on the organization and function of the genome in elite athletes and aims to develop molecular methods that may be used for sports medical practices, personalized exercise training, nutrition prescription and the prevention of exercise-related injury and/or disease (Guilherme & Lucía, 2019; Ahmetov et al., 2022).

According to Hasin et al. (2017) genomics is the most mature of the "omics" fields. In the realm of medical research, genomics focuses on identifying genetic variants associated primarily with disease, and response to treatment, as well as other applications, namely supplement efficacy and future patient prognosis. Genome-wide association studies (GWAS) have involved thousands of individuals who have been genotyped for more than a million genetic markers, and statistically significant differences in minor allele frequencies between cases and controls are considered evidence of association. GWAS provide an invaluable contribution to our understanding of complex phenotypes. Associated technologies include genotype arrays (Voight et al., 2012; Wang et al., 2009), whole-genome sequencing and exome sequencing (Ng et al., 2009).

Metabolite levels and relative ratios reflect metabolic function, and out of normal range perturbations are often indicative of disease. Quantitative measures of metabolite levels have made possible the discovery of novel genetic loci regulating small molecules, or their relative ratios, in plasma and other tissues (Ghazalpour et al., 2014; Shin et al., 2014; Kettunen et al., 2012; Gieger et al., 2008). Additionally, metabolomics in combination with modeling has been used extensively to study metabolite flux. Associated technologies include MS-based approaches to quantify both relative and targeted small molecule abundances (Madsen et al., 2010; Patti et al., 2012).

This analysis has stimulated great interest in the field of exercise/sport, not only for commercial reasons (such as development of sport supplements), but also for personalized nutrients and dietary management of different diseases (Bruce et al., 2010). It is recognized that genetics, genomics and other multi-omics are among the fastest advancing scientific fields, prompting innovation in many disciplines including sport and exercise science. It has been surmised that that metabolism and gene-diet interaction in particular, may play a crucial role in how athletes or individuals respond to such phenolic-rich diets, including Rooibos.

In summary it has become apparent that it is important to understand the fate of metabolites and molecular mechanisms of polyphenolic compounds found in indigenous plants such as Rooibos, and also to better recognize how these mechanisms translate into their protective and modulatory effects (Guest et al. (2019), because these properties may in turn promote improved performance during sport and exercise, as well as enhancing recovery.

### 1.3 Ethnobotany, Rooibos and the Cape Floral Region

The area of interest for this paper converges on the South Western tip of South Africa, which is characterized by its unique flora and is known in biogeographical terms as the Cape Floral Region because it is very distinct from that of the surrounding areas (Born et al., 2007). The diversity of the flora is substantial, with over 9086 species of vascular plants in its area of 90,000 km2 (Goldblatt et al., 2005; Manning & Goldblatt, 2012), which according to Cowling et al. (1992) is comparable to that of equatorial rain forests. Interestingly, the species level endemism (68.8%) is comparable to that found on islands, and is unusual for mainland sites (Linder, 2003).

More specifically the plant Rooibos, Aspalathus linearis (Brum.f) Dahlg. (Family Fabaceae; tribe Crotalarieae) is indigenous to the Cederberg and neighboring mountains of the Western Cape Province of South Africa and was reportedly used as an herbal beverage by the indigenous Khoi people (Morton, 1983).

Rooibos in general and Rooibos herbal tea in particular is not just a herbal remedy that soothes and invigorates both young and old but is a natural herb unique to the South African Cederberg Mountains of the Western Cape Province. The natural herb is processed into a naturally soothing drink, sweet in taste, naturally caffeine free, additive free, preservative free, colorant free and very low in tannin (DAFF, 2013). Rooibos is known

to have antioxidant qualities (Blommaert et al., 1978) and is an important dietary source of antioxidants containing mostly flavonoids, but also the unique C–C linked dihydrochalcone glucoside aspalathin (Koeppen, & Roux, (1965) and cyclic dihydrochalcone, aspalalinin (Shimamura et al., 2006). As such Rooibos has gained increasing popularity as a health/functional beverage both locally and worldwide (Joubert et al., 2008; Joubert and Schulz, 2006).

A commonly cited reference point for the identification of Rooibos, relates to the work of the botanist Carl Thunberg, who wrote: "Of the leaves of the Borbonia cordata [an earlier classification of Aspalathus] the country people made tea" (Thunberg, 1986:44). From this, Wynberg (2017) noted that it has been surmised that Rooibos herbal tea was inherited from San and Khoi traditions. A study by the South African government by the Department of Environmental Affairs (DoEA) indicated that the Khoi and San indigenous peoples appear to be the first users of Rooibos as a beverage. The same study has intimated that traditional knowledge (TK) in the use of Rooibos was likely passed down from generation to generation by the Khoi and San indigenous people before the arrival of European settlers in South Africa (DoEA, 2014); however, it is important to emphasize that this assertion is not based on empirical evidence.

Thus, such observations and insights emphasize the importance of rigorous historical analysis and therefore some uncertainty should be associated with non-evidence based assertions, because as such these are not necessarily definitive. Even so Wynberg (2017) makes the point that while San and Khoi were part of an oral culture it is reasonable to contend that the absence of a historical record does not conclusively prove anything. The same author pragmatically summarizes that one must leave aside questions of priority, because "it is indisputable in [her] view that the rooibos industry drew from traditional use and knowledge, in whatever guise these were manifest" (Wynberg, 2017:43).

### 1.4 Indigenous knowledge, indigenous plants and traditional medicine

Kayser (2018) forwards the view that even though our ancestors did not have any detailed knowledge about chemical structures; it is quite clear those natural products that they had access to formed the basis of many medicines. The reasons for this are manifold and Kayser believes, but it is likely that the ability of nature to create fantastic complex and structurally diverse molecules is the most convincing argument that natural products show very broad biological activity.

According to the World Health Organization medicinal plants are important elements of indigenous medical systems (WHO, 2013); which is reflected by a review by Zhang (2002) that indicates that approximately 80% of the world's population currently rely on indigenous or traditional medicines for their primary health needs. Most of these therapies involve the use of aqueous solutions of plant extracts. It is therefore not surprising that the historical development of pharmaceuticals and other novel drugs has proceeded primarily through the extraction of efficacious compounds from such plants (Farnsworth and Bingel, 1977). This implies that the customary use of these plants by indigenous groups of people was informed by traditional knowledge systems, which in turn has allowed pharmaceutical corporations and similarly aligned industries to more readily identify plants that were likely to have therapeutic benefits and importantly have commercial and medical potential for drug development. This observation is endorsed by Farnsworth et al. (1985) who believe that 74% of all pharmaceutical drugs have been derived from plants.

It is of particular interest for the reader to recognize that many of the species found in the Cape Floral Kingdom are also used in traditional medicine (Van Wyk & Gorelik, 2017). According to Born et al. (2007) the first person to attempt to provide a systematic and comprehensive account of Cape medicinal plants was accorded to Ludwig Pappe the first professor of botany at the South African College, which was presented in his tome 'Florae Capensis Medicae Prodromus' (or: An Enumeration of South African Plants used by the Colonists of the Cape of Good Hope) (Pappe, 1868). This forms a vital historical account of the best-known medicinal plants in use during the middle of the 19th century, which profiles 101 items, including 97 vascular plants, two algae, one fungus and one animal product (hyraceum). An additional contribution was made by the academic Andrew Smith, whose research remains the first and foremost botanical text of Xhosa indigenous knowledge (NISC, 2023). According to Born et al. (2007) during the late 19th century Andrew Smith added to the work of Ludwig Pappe and listed so

called "native" remedies according to ailments in his "A contribution to the South African Materia Medica" (Smith, 2011).

Van Wyk & Gorelik (2017) noted that in general terms the ethnobotany of Cape plants has remained poorly recorded despite the global scientific interest in both the unique flora and the indigenous Khoisan people. The same authors reflect that it is a great pity that there has not been any attempt at a systematic study of the medicinal and other useful plants during the 17th and 18th centuries. While there have been some illuminating ethnographic studies, summarized in Schapera (1930); however, it is unfortunate that these include only general accounts of useful plants without details about the species and the exact ways in which they were used.

Therefore, a question that begs to be answered is how did the European settlers identify Rooibos not only as a beverage, but also for its potential medicinal use, when it is but one of over 9000 species of plants found in the region. The knowledge and use of Rooibos most likely pre-dated the arrival of Europeans. However, the extensive usage of Rooibos by inhabitants of the Cape during the 17th to 20th century was documented and also included the commercialization of Rooibos by a Russian immigrant Benjamin Ginsberg who started commercial Rooibos trading in 1904 (Joubert & de Beer, 2011).

It appears that Japanese and South African researchers were the first to scientifically investigate the possible health promoting properties of Rooibos, which led to publications reporting on various biological activities (Snykers et al., 1974; Hessling et al., 1979; Yoshikwa et al., 1990; Saski et al., 1991; Inanami et al., 1995). More specifically Rooibos has been shown to be antimutagenic (Marnewick et al., 2000, 2004) and cancer modulating (Marnewick et al., 2005, 2009). Furthermore research by Marnewick and colleagues provided the first clinical evidence in humans that chronic consumption of rooibos for 6 weeks significantly improved several biomarkers of blood lipid status (Marnewick et al., 2011). In addition, the study also provided supporting evidence that Rooibos reduced oxidative stress by significantly decreasing lipid peroxidation and improving the glutathione redox status of adults at risk for developing cardiovascular disease (CVD). The researchers suggested that results from this study are optimistic, contributing to our present understanding of the health promoting properties of Rooibos and therefore definitely warrant further studies in this field. More recently this prompted an exploratory study into the efficacy of the fynbos plant Rooibos (Aspalathus linearis) to reduce and/or prevent acute mountain sickness (AMS). A pilot study was initiated with an expedition climbing team, attempting to ascend Aconcagua (6962 m) in the Andes, Argentina, the highest peak in the world outside of the Himalaya Mountain Range. Preliminary findings suggest the potential of the Rooibos plant to reduce the symptoms and/or onset of AMS for those persons ascending to high altitudes, whether for sport, leisure or for work (Davies et al., 2019a).

This paper has a keen interest in the indigenous plant Rooibos (Aspalathus linearis), which as previously noted has unique bioactive compounds that have reported therapeutic benefits (Pantsi et al., 2011; Marnewick et al., 2011) and possibly as a prophylaxis for sojourners at high altitude (Davies et al., 2019a). In particular Rooibos is an indigenous plant of significant interest because traditionally, Rooibos has a long history of medicinal use with anecdotal evidence linking the consumption to relief of digestive disorders, skin allergies, insomnia, nervous tension and mild depression (Morton, 1983; Van Wyk et al., 1997).

### 1.5 Ergogenic aids

The search for dietary supplements and / or substances that enhance sport performance, typically referred to, as ergogenic aids is as ancient as sports themselves. Dietary fads are known from ca. 500–400 B.C., when athletes and warriors used products such as deer liver and lion heart to impart certain benefits, hoping that consumption would produce bravery, speed or strength (Mayer and Bullen, 1960; Reed, 1977; Van Itallie et al., 1956; Williams, 1989).

The field of sports and exercise science has historically prioritized research into nutritional strategies to optimize performance and from these investigations best-practice evidence-based recommendations and position stands have been developed (Goldstein et al., 2010). It is becoming increasingly apparent that many athletes and sports professionals are ingesting plant phytochemicals with known antioxidant qualities in an attempt to minimize the effects of oxidative stress during physical activity, including Rooibos (Aspalathus linearis) (Marnewick et al., 2011); Ginkgo biloba (Rong et al., 1996); as well as oligomeric proanthocyanidins (OPCs), and polymers of flavanols found in grape extract (Lafay et al., 2009). Additionally, nutritional antioxidant supplements such as

selenium, vitamin C and E health impacts have been well explored within an exercise context in attempts to counteract and/or minimize effects of reactive oxygen species (ROS) (Packer, 1997), as well as glutathione (Gohil et al., 1998). In summary a nutritional ergogenic aid is a substance found in the diet that is ingested to produce improved or enhanced sport, exercise, and physical performance (Bala & Bhalla, 2022). The same author goes on to say that an ergogenic aid is ingested with the view that it helps an individual to tolerate heavy training to a greater degree by helping them recover faster or help them stay injury free and healthy during intense training. Some studies show that supplementation with a known ergogenic aid can significantly enhance exercise performance e.g. helps athletes run faster, lift more weight, or carry out more work during a given physical exercise task. On the other hand, it can also enhance recovery from exercise. Such supplementation, it is argued, has the potential to improve training performance and post exercise recovery and therefore can be considered to be ergogenic.

It is not surprising therefore to note that multiple categories of ergogenic aids have been identified, developed and introduced with the aim to enhance exercise or sports performance and these have been typically categorized in terms of their pharmacological, physiological, nutritional, mechanical, or psychological mechanisms (Bishop, 2010; Londe et al., 2018; Marocolo et al., 2018, 2019). According to Mota & Marocolo (2022) the use and application of these ergogenic strategies are used in the belief that they may improve energy readiness and/or accelerate the recovery course (chronically or acutely), and eventually augmenting performance. However, it is somewhat problematic that many athletes commonly use these ergogenic aids even without any scientific evidence (Bishop, 2010; Marocolo et al., 2018).

According to Mota & Marocolo (2022), researchers should perform studies meeting the main research design issues, such as dose of the intervention/substance; background of volunteers (e.g., professional; amateur); specific exercise type (e.g., strength, endurance); and well-controlled studies (e.g., placebo; double-blind) in order to establish the efficacy of the substance as an ergogenic aid. A further complicating issue has been that these studies often present differing findings and are often equivocal. Thus while some studies that have tested nutritional and/or supplementation strategies, may have shown beneficial effects on exercise performance and/or recovery, these effects are not universal (Mota & Marocolo, 2022).

Bala & Bhalla (2022) noted that the ingestion / use of ergogenic aids is varied. At one end of the spectrum of ergogenic aids are normal foods and at the other are substances that are clearly drugs. In between, however, are a few compounds that are more difficult to classify. The term includes a number of foods, including for example those high in carbohydrates (Maughan, 1999), and carbohydrate–electrolyte sports drinks, whose effectiveness in improving exercise capacity is according to Williams (1998) beyond doubt.

Due to the changing nature and availability of ergogenic aids and/or those purporting to have such properties different international institutions periodically publish position stands that are elaborated to guide the practice of supplementation, such as the Australian Institute of Sport (AIS) (Moreno et al., 2022). Daher et al. (2022) in their scoping review explored the prevalence of dietary supplement use among athletes worldwide, in terms of the most commonly used supplements, their sources of information on dietary supplements and their reasons for use of these supplements. They reflected on a prevalence study by Garthe & Maughan (2018) that indicated an estimated prevalence of dietary supplement use among athletes to be between 40% and 100%, depending on several factors including the level of competition, type of sport, and the definition of dietary supplement. It may be reasonable to argue that the increased ease of access to these supplements via the internet, makes it possible for athletes and sports people to easily purchase these products all over the world, and may also explain their exponential increase in usage in recent times.

### 1.6 Policy and legislation

It was highlighted at the start of this treatise that wealth and technology continue to be concentrated in the north as biodiversity and poverty continues to perpetuated in the South (Reid et al., 1993). However, there has been a significant shift in the business environment that increasingly recognizes its responsibilities in respect to environmental, social and governance (ESG) issues. Within the South African context there has been recognition of the high conservation value of the country's biodiversity along with action directed towards the sustainable development of the nation's natural resources for economic development.

South Africa became signatory to the Nagoya Protocol in January 2013, a legal framework that seeks to address the concept of Traditional Knowledge (TK) and Indigenous Knowledge (IK) in relation to the use of genetic resources, along with mutually agreed terms for granting access, and the benefit-sharing and compliance obligations. The benefit-sharing regulations aim to reduce the current disparity between developing and developed nations, notably the global north versus the global south regarding fair and transparent benefit-sharing as a result of the commercial utilization of the genetic resource (Nagoya protocol, 2010).

In particular, the Convention on Biological Diversity (CBD) was a breakthrough in global policy making. It combined a concern for the environment with a commitment to resolving longstanding human injustices regarding access to and use of biological resources. The CBD aims to conserve biodiversity, achieve its sustainable use, and reward its custodians with fair and equitable benefit sharing (Schoeder et al., 2020).

The South African government, along with support from various non-government organizations ratified the United Nations Convention on Biological Diversity in 1995 (Wynberg, 2017). In 2004 the South African National Environmental Management Biodiversity Act (NEMBA) was promulgated, which prescribed benefits from the use of biological resources that included that these are shared with the holders of traditional knowledge (TK), especially those indigenous communities associated with such TK (NEMBA, 2004). Therefore, within South Africa the alignment of legislation with commercial interests has better protected the rights of indigenous peoples and holders of traditional knowledge, which in turn has identified bioprospecting as an important mechanism to create incentives for conservation (Wynberg, 2017).

A positive consequence of these legislative and policy developments was the signing of an Access and Benefit-sharing (ABS) agreement between the Rooibos Industry, represented by the South African Rooibos Council (SARC) and the Khoi-Khoi and San, represented by the National Khoi-San Council (NKC) and the South African San Council (SASC). This agreement will see the Khoi-Khoi and San communities benefit from the commercialization of Rooibos (SARC, 2022). The Rooibos Benefit Sharing Agreement (RBSA) was the first comprehensive, industry-wide benefit sharing agreement, and globally without parallel. It is exceptional as it not only spans an entire industry, but also because the product is already on the market (Schoeder et al., 2020).

While such policy commitments are welcome, it was the work of the South African Rooibos Council, which saw Rooibos receiving the important commercial registration for Protection Designation of Origin (PDO) in the European Union (EU) that perhaps best illustrates how the successful enactment of an influential trading endorsement protects the industry from predatory corporates, while at the same time ensuring better recognition of stakeholders in the Rooibos value chain, notably the indigenous communities. Therefore, as a signatory to the Nagoya Protocol, and the other aligned legislation and policy evolvements both globally and nationally South Africa requires industries that trade in indigenous biological resources, such as Rooibos, to share benefits with traditional knowledge holders in a fair and equitable way.

### 1.7 Business imperatives

A key aspect of this transdisciplinary study is that it hinges on fundamental business imperatives. Simply put the ongoing study is dependent on funding support from the South African Rooibos Council, which in turn is dependent on the viability and success of the Rooibos industry to support its work, which is espoused via its mission statements, firstly that 'SARC will use available resources to effectively and efficiently promote, grow and protect the Rooibos industry of South Africa for its stakeholders, locally and internationally' and secondly that 'SARC will support appropriate research and communication to promote the benefits of Rooibos'.

Therefore it needs to be acknowledged that SARC has a clear commitment to support appropriate research to promote the benefits of Rooibos in order to protect the industry from misrepresentation and deceptive marketing ploys, which to some extent have plagued other aspects of the sport supplement industry, especially in regard to those substances that purportedly have ergogenic properties. This concern was evidenced as far back as 1989 when the National Council for Health Fraud established a task force to investigate ergogenic aids (Lightsey & Attaway, 1992). In light of the expectations of the SARC it was necessary that the present study fully complied with best experimental research practices and research ethics principles so that any findings that may support and promote the Rooibos industry are transparent, peer reviewed and premised on best global standards.

As intimated earlier many diverse cultures attribute health benefits to foods and plants, and food companies, in their commercial strategies, have used this coining some foods as "functional foods" (Arai, 1996), because of their chemical composition and their hypothetical health effects (Richardson, 1996; Roberfroid, 1997). In terms of the sport supplement market athletes will invariably try to improve their diet especially for assumed performance gains derived from these "dietary ingredients". The sources of these ingredients come from minerals, plants, extract tissues or are chemically synthesized or processed (Kerksick et al., 2018). The final product, which is often commercialized and sold by companies, is consumed by athletes and the general population alike (Knapik et al., 2016).

It is not surprising therefore to observe how the food industry has invested a lot in the creation, design, presentation, and distribution of these products, making them very attractive not only for professional athletes, but also to recreational athletes, and even to the general population. According to GrandView (2023) the global sports nutrition market size was valued at USD 42.9 billion in 2022 and is expected to expand at a compound annual growth rate (CAGR) of 7.4% from 2023 to 2030. This economic niche also attracts a multi-level marketing system, in which wellness (which includes sport supplements) represents 35 % of sales (Cardenas & Fuchs-Tarlovsky, 2018). Given the bioactive compounds found in Rooibos it has been suggested by Davies et al. (2023ab) that if Rooibos is prepared as an iced tea and/or similar beverage in a manner that retains aspalathin and isoorientin contents then there appears to be a reasonable opportunity to develop it as an effective sport drink and potential ergogenic aid with commercial possibilities.

## 2 RESULTS

### 2.1 Preliminary findings

As indicated earlier in this article the overall transdisciplinary research approach is built around a key pivotal experimental project investigating whether Rooibos an indigenous South African plant with its unique bioactive compounds modulates oxidative stress and potentially acts as an ergogenic supplement. It is important to emphasize that the two experimental studies were not done in isolation but also considered social, economic and sustainability issues.

Both studies conformed to the principles of the Helsinki Accord and were approved by the Institutional Faculty of Health and Wellness Sciences Research Ethics Committee at the Cape Peninsula University of Technology (Research ethics approval number: CPUT/HWS-REC2011/H02 and CPUT/HWS-REC 2018/H2) for a randomized, blinded placebo controlled cross over experimental design. One study focused on the upper body, which involved the participants (n=32 male adults, mean age 22.2 years) performing a maximal fatiguing elbow extension/flexion exercise including 5 sets of 15 all-out voluntary contractions separated by 10-second intervals on a Biodex System 3 at a speed of 60º per second (Davies et al., 2019b). The second study concentrated on the lower body and required the participants (n=30 male adults, mean age 25.95 years) to perform a modified submaximal ramp test to 80% maximal effort on a Wattbike cycle ergometer (Davies et al., 2023b).

In both studies an acute dose of Rooibos or placebo was ingested shortly prior to exercise, however in the upper body test the method of ingestion was via a capsule that contained a fermented rooibos extract (standardized with a content of ~340 mg of total rooibos polyphenols). While in the lower body test the delivery was via a Rooibos or placebo beverage, which included 1.6 g of a commercially available standardized fermented Rooibos powdered extract dissolved into 375 mL beverage of peach apricot flavored water.

The results from the upper body test indicated that during elbow flexion in the Rooibos trial (when compared to the placebo) the participants exhibited consistently greater peak torque (Nm) and also more total work (joules) across the five maximal exercise bouts (Davies et al., 2019b). While the lower body submaximal test results on the WattBike indicated that during the Rooibos beverage intervention the participants on average were able to exercise for longer and therefore complete a greater distance and higher mean power when compared to the placebo trial. The percentage increase in distance was around 15.0% (Davies et al., 2023b).

As the study evolved additional elements have been factored in namely additional education and training in "omics" notably in metabolomics and genomics. The progress of the study also involved the integration of issues

relating to economic, social and policy considerations (as espoused in greater detail in the literature review), which were presented at annual review progress report meetings to the South African Rooibos Council (SARC) and at the CPUT Postgraduate Conferences (Kamati, 2020; Kamati et al., 2022a: Kamati et al., 2022b) as well as presentations at international conferences (Davies et al., 2018; Kamati et al., 2021; Davies et al., 2023; Bragagna et al., 2023). As a consequence of the "omics" phase of the ongoing study a substantive array of biotechnology findings will be released in due course at conferences, workshops and in peer reviewed journals.

## 3 DISCUSSION

Nicolescu (2012) argues that the need for transdisciplinarity is necessary and realistic in order for universities to survive as it forces them to interact with different stakeholders. This is because it is becoming ever more apparent that many challenges facing mankind are complex and manifold, such as the climate emergency, poverty and social unrest. At a more nuanced level it is becoming increasingly important for academics and researchers who work at universities in the field(s) of science, engineering and technology to appreciate and understand that they operate in a context, which is informed and shaped by environmental, cultural, political, economic and historical imperatives. Thus the consequences of their work will invariably impact either positively or negatively in the broader context of a global society.

As Pohl and Hardorn (2008) posited that transdisciplinary studies and approaches have the potential and capacity to alleviate life's deep-seated challenging problems in the world as it uses integrated, practice-oriented and normative knowledge systems.

Notably, transdisciplinary moves beyond interdisciplinary by engaging with production, use of knowledge and involving both academic and non-academic stakeholders in the process (Chuenpagdee 2018). Thus, the transdisciplinary approach surpasses interdisciplinary and multi-disciplinary approaches as it better addresses complex problems (Back, Greenhalgh-Spencer & Frias, 2015).

It is therefore abundantly apparent, as the biggest suppliers and channels of knowledge (Brennenraedts, Bekkers & Verspagen, 2006), universities are expected to play an important role of providing a platform to facilitate transdisciplinarity, which engages production, use of knowledge and involvement of non-academic stakeholders across different disciplines and communities to solve problems. These considerations are particularly relevant in South Africa, which is characterized by the prevalent conditions of poverty, underdevelopment, legacies of colonialism along with the systemic and negative consequences of legislative discrimination against non-white people under Apartheid.

Thus the Cape Peninsula University of Technology (CPUT) which is the primary institution for the research project into the modulatory effects of Rooibos has since its inception been committed to research and technology innovation with a clear strategic view that the research institutes and centers should be enabled to operate cross-faculty in support of the institutional commitment towards trans-disciplinary approaches (CPUT, 2022). The institutional predilection towards transdisciplinarity as espoused by CPUT has facilitated the present evolvement of the Rooibos research study into its potential ergogenic properties. In the first instance the ability to conduct the study was premised on cooperation to initiate the project between the Applied Microbial and Health Biotechnology Institute (AMHBI), a research-intensive entity situated outside of any specific faculty at the university and the Centre for Sport Business and Technology Research (CSBTR) which is housed within the Sport Management Department in the Faculty of Business and Management Sciences. The viability of the TD project within the institutional commitment towards TD was built on the strength and experience of the researchers in the areas of biochemistry and health biotechnology alongside with sport science and business.

The existing expertise allowed for the study design into health biotechnology and sport science research project that further engaged with business applications, notably in terms of beneficiation of a potential sport ergogenic supplement in a lucrative global market. Further dimensions of the study spoke to the need for policy enactments that respect IK and those communities who underpin the Rooibos industry. The study was augmented from a teaching viewpoint in terms of the innovative developments in "omics" and the need to collaborate with other institutions, notably North West University and Stellenbosch University in South Africa and the University of Vienna in Austria to facilitate the education and training, as well as new analytic techniques.

## CONCLUSION

The preliminary findings that are based on the SARC commitment to "support appropriate research and communication to promote the benefits of Rooibos" shows that the application and utilization of Rooibos as a potential ergogenic aid may have benefits in both submaximal exercise and maximal exhausting exercise. The full biochemistry, metabolic mechanisms and/or genomic characteristics that make this possible will be shared in due course as the study matures and peer reviewed publications are released.

The confluence of diverse skills and backgrounds gave particular impetus to the study into the potential ergogenic properties of Rooibos, which reflected the significant advantages of a TD approach and the contributions made by the researchers and academics along with stakeholders in the Rooibos industry. As Van der Bijl-Brouwer et al. (2021) asserted transdisciplinarity can foster flexibility in innovation and partnership approaches and help evolve how we work with what we learn and how we collaborate with others. It is argued that the multi-factored outputs and benefits that have emanated from the project, and those to be disseminated in due course demonstrate the value of TD in a world where science, society and environmental issues ought to be given fair and equal consideration.

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## REFERENCES

Ahmetov, I.I. Hall, E.C.R. Semenova, E.A. Pranckevičienė, E., & Ginevičienė, V. (2022). Advances in sports genomics. *Advances in Clinical Chemistry*, 107, 215-263. doi: 10.1016/bs.acc.2021.07.004

Amnesty International (2020). Broken and unequal, the state of education in South Africa. https://creativecommons.org/licenses/by-nc-nd/4.0/legalcode

Appel, J., & Kim-Appel, D. (2018). Towards a Transdisciplinary View: Innovations in Higher Educat. International Journal of Teaching and Education, VI(2), 61-74, https://10.20472/TE.2018.6.2.004

Arai, S. (1996). Studies on functional foods in Japan–state of the art, *Bioscience, Biotechnology, and Biochemistry*, 60 (1), 9–15.

Back, S.M., Greenhalgh-Spencer, H., & Frias, M.F. (2015). 'The application of transdisciplinary theory and practice to STEM education', in Y. Rosen, S. Ferrara & M. Mosharraf (eds.), *Handbook of research on technology tools for real-world skill development* (pp. 42–67), IGI Global, Hershey, PA.

Bala, A., & Bhalla, S. (2022). Ergogenic aids for improving athletes' performance: An overview. *International Journal of Physiology, Nutrition and Physical Education*, 7(1), 371-373.

Bishop, D. (2010). Dietary supplements and team-sport performance. Sports Medicine, 40, 995–1017. doi: 10.2165/11536870-000000000-00000

Blommaert, K.L.J., & Steenkamp, J. (1978). Tannien-en moontlike kafeieninhoud van rooibostee, Aspalathus (subgen. Nortiera) linearis (Brum. Fil) R. Dahlgr. *Agroplantae*, 10, 49.

Bongiovanni, T., Lacome, M., Fanos, V., Martera, G., Cione, E., & Cannataro, R. (2022). Metabolomics in Team-Sport Athletes: Current Knowledge, Challenges, and Future Perspectives. *Proteomes*, 10, 27. https://doi.org/10.3390/ proteomes10030027

Born, J., Linder, H.P., & Desmet, P. (2007), *The Greater Cape Floristic Region. Journal of Biogeography*, 34, 147-162. https://doi.org/10.1111/j.1365-2699.2006.01595.x

Bragagna, L., Kamati, O.V., Stürmer, V., Gassner, M., Maqboul, L., Davies, S.E.H., Marnewick, J.L., & Wagner, K-H. (2023). *Single-dose effect of rooibos herbal tea on oxidative stress markers in healthy males*. *Redox Congress*. June 6–9, 2023, in Vienna, Austria.

Bouchard, C., Rankinen, T., & Timmons, J.A. (2011). Genomics and Genetics in the Biology of Adaptation to Exercise. *Comprehensive Physiology*, 1, 1603–1648.
Brennenraedts, R., Bekkers, R., & Verspagen, B. (2006). The different channels of university industry knowledge transfer: *Empirical evidence from biomedical engineering*. https://citeseerx.ist.psu.edu/viewdoc/download ?doi=10.1.1.543.6736&rep=rep1&type=pdf
Bruce, S.J., Breton, I., Decombaz, J., Boesch, C., Scheurer, E., Montoliu, I., Rezzi, S., Kochhar, S., & Guy, P.A. (2010). A plasma global metabolic profiling approach applied to an exercise study monitoring the effects of glucose, galactose and fructose drinks during post-exercise recovery. *Journal of Chromatography* B: Analytical Technologies in the Biomedical and Life Sciences, 878(29), 3015–3023.
Cardenas, D., & Fuchs-Tarlovsky, V. (2018). Is multi-level marketing of nutrition supplements a legal and an ethical practice? *Clinical Nutrition*, ESPEN 25, 133–138.
Chuenpagdee, R. (2018), *Transdisciplinarity for small-scale fisheries governance: Analysis and practice*, Springer, St. John's.
Cowling, R.M. (1992). *The ecology of fynbos: nutrients, fire and diversity*. Oxford University Press, Cape Town.
Cape Peninsula University of Technology (CPUT) (2022). Cape Peninsula University of Technology Vision. https://www.cput.ac.za/research-technology-and-innovation/centres.
Department of Agriculture, Forestry & Fisheries (DAFF) (2013): *A Profile of the South African Rooibos Tea Market Chain.*
http://webapps.daff.gov.za/AmisAdmin/upload/ROOIBOS%20TEA%20MARKET%20VALUE%20CHAIN%20 PROFILE%202014.pdf
Daher, J., Mallick, M., & El Khoury, D. (2022). Prevalence of Dietary Supplement Use among Athletes Worldwide: A Scoping Review. *Nutrients*, 14, 4109. https://doi.org/10.3390/nu14194109
Daneshpour, H., & Kwegyir-Afful, E. (2022). *Analysing Transdisciplinary Education: A Scoping Review*. Science & Education, 31, 1047–1074. https://doi.org/10.1007/s11191-021-00277-0
Davies, S.E.H., Marnewick, J.L., West, S., Taliep, S.M., & Rautenbach, F. (2018). *Antioxidant supplementation and exercise induced fatigue: The potential of rooibos aspalathius linearis.* 7th International Ergonomics Conference, ERGONOMICS 2018. Zadar, Croatia, 13-16 June 2018: ISSN 1848-9699 (Print) ISNN 2584-5012 (USB), pages 95-103.
Davies, S.E.H., Marnewick, J.L., and West, S. (2019a). Rooibos Aspalathus linearis – Can it reduce the incidence and severity of acute mountain sickness? A case study of Aconcagua (6962 m). *African Journal of Physical Activity and Health Sciences*, 25(2): 232-251. 2019-07-30.
https://www.ajol.info/index.php/ajpherd/article/view/188543
Davies, S.E.H., Marnewick, J.L., West, S., Taliep, S.M., Rautenbach, F., & Gamieldien, R. (2019b). 'The efficacy of rooibos Aspalathus linearis as an ergogenic aid during exercise'. *International Journal of Human Factors and Ergonomics*, 6(1), 88-102. DOI:10.1504/IJHFE.2019.10021010
Davies, S.E.H., Marnewick, J.L., Kamati, O.V., & Bester, D. (2023a). *The power of transdisciplinary research for business innovation: The case of Rooibos as a potential ergogenic sport drink*. 8th International Conference on Business and Management Dynamics, 7 – 8 September 2022, South Africa. Published in peer reviewed proceedings. Current Aspects in Business, Economics and Finance Vol. 8. Editor Dr. Chun-Chien Kuo. Publisher - B P International ISBN-13 (15) 978-81-19039-04-3 (Print); ISBN-13 (15) 978-81-19039-06-7 (eBook). Print ISBN: 978-81-19039-04-3Online ISBN: 978-81-19039-06-7 DOI Number:
https://doi.org/10.9734/bpi/cabef/v8/4496
Davies, S.E.H., Marnewick, J.L., Kamati, O.V., & Bester, D.J. (2023b). *Transdisciplinary Synergy: The Benefits for Postgraduate Learning and Research Through Integrated Support at a University of Technology in South Africa.* The Paris Conference on Education (PCE2023), Maison de la Chimie, Paris, France, | Friday, June 16, 2023 to Monday, June 19, 2023.
Deschepper, R., Six, S., Vandeweghe, N., De Couck, M., Gidron, Y., Depoorter, A.-M., & Bilsen, J. (2017). Linking numbers to perceptions and experiences: Why we need transdisciplinary mixed-methods combining neurophysiological and qualitative data. *Criminal Justice and Behavior*, 10(2), 1609–1629. https://doi.org/10.1177/0093854820953449

Department of Environmental Affairs (DoEA) (2014). *Traditional Knowledge Associated with rooibos and honeybush Species in South Africa*; 2014.
https://www.dffe.gov.za/sites/default/files/reports/traditionalknowledge_rooibosandhoneybushspecies_report.pdf
Engelbrecht, P. (2006). The implementation of inclusive education in South Africa after ten years of democracy. *European Journal of Psychology of Education*, 21(3), 253-264. http://download.springer.com/static/pdf/625 art%253A10.1007%252FBF03173414.pdf?auth66=1393688373_906fca13d83dd82e8dff7e7b10f80b93&ext=.pdf
Farnsworth, N.R., Akerele, O., Bingel, A.S., Soejarto, D.D., & Guo, Z. (1985). *Medicinal plants in therapy*. Bulletin of the World Health Organisation, 63, 965–981.
Farnsworth, N.R., & Bingel, A.S. (1977). *Problems and prospects of discovering new drugs from higher plants by pharmacological screening*. In: Wagner, H., Wolff, P. (Eds.), New Natural Products and Plant Drugs with Pharmaceutical, Biological or Therapeutic Activity. Springer-Verlag, Heidelberg, Germany.
Fiehn, O. (2001). Combining Genomics, Metabolome Analysis, and Biochemical Modelling to Understand Metabolic Networks. Comp. Functional. Genomics, 2, 155–168.
Fortuin, K. P. J., & Van Koppen, C. S. A. (2016). Teaching and learning reflexive skills in inter-and transdisciplinary research: A framework and its application in environmental science education. *Environmental Education Research*, 22(5), 697–716.
Garthe, I., & Maughan, R.J. (2018). Athletes and Supplements: Prevalence and Perspectives. *The International Journal of Sport Nutrition and Exercise Metabolism*, 28, 126–138.
Gieger, C., Geistlinger, L., Altmaier, E., Hrabe de Angelis, M., Kronenberg, F., Meitinger,. T, et al. (2008). Genetics meets metabolomics: a genome-wide association study of metabolite profiles in human serum. *PLoS Genetics*, 4:e1000282
Ghazalpour, A., Bennett, B.J., Shih, D., Che, N., Orozco, L., Pan, C., et al. (2014). Genetic regulation of mouse liver metabolite levels. *Molecular Systems Biology*, 10:730.
Ginevičienė, V., Utkus, A., Pranckevičienė, E., Semenova, E.A., Hall, E.C.R., & Ahmetov, I.I. (2022). Perspectives in Sports Genomics. Biomedicines, 10, 298. https://doi.org/10.3390/biomedicines10020298
Glittenberg, J. (2004). A transdisciplinary, transcultural model for health care. *Journal of Transcultural Nursing*, 15(1), 6–10.
Gohil, K., Viguie, C., Stanley, W.C., Brooks, G.A., & Packer, L. (1988) 'Blood glutathione oxidation during physical exercise'. *Journal of Applied Physiology*, 64(1), 115–119.
Goldblatt, P., Manning, J.C., & Snijman, D. (2005) Cape plants: corrections and additions to the flora. 1. *African Biodiversity & Conservation*, 35, 35–46.
Goldstein, E.R., Ziegenfuss, T., Kalman, D., Kreider, R., Campbell, B., & Wilborn, C. (2010). International society of sports nutrition position stand: caffeine and performance. *Journal of the International Society of Sports Nutrition*, 7(1), 5. doi:10.1186/1550-2783-7-5. PMID:20205813.
Guest, N.S., Horne, J., Vanderhout, S.M., & El-Sohemy, A. (2019). Sport nutrigenomics: Personalized nutrition for athletic performance. *Frontiers in Nutrition*, 6(February), 1–16.
Guilherme, J.P.L.F., & Lucía, A. (2019*). Introduction to genetics of sport and exercise.* In Sports, Exercise, and Nutritional Genomics: Current Status and Future Directions; Barh, D., Ahmetov, I., Eds.; Academic Press: Cambridge, MA, USA, 2019; pp. 3–22.
GrandView (2023). *Sports Nutrition Market Size, Share & Trends Analysis Report By Product Type (Sports Supplements, Sports Drinks)*, By Application, By Formulation, By Consumer Group, By End-user, By Sales Channel, By Region, And Segment Forecasts, 2023 – 2030.
https://www.grandviewresearch.com/industry-analysis/sports-nutrition-market
Hadorn, G.H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Hoffman-Riem, H., Joye, D., Pohl, C. et al., (2008). '*The emergence of transdisciplinarity as a form of research*', in G.H. Hardon, H. Hoffman-Riem, S. Biber-Klemm, W. Grossenbacher- Mansuy, D. Joye, C. Pohl, et al. (eds.), Handbook of transdisciplinary research, (pp. 19–39), Springer, Bern.
Hasin, Y., Seldin, M., & Lusis, A. (2017). Multi-omics approaches to disease. *Genome Biology*, 18(83), DOI 10.1186/s13059-017-1215-1

Hesseling, P.B., Klopper, J.F., & Van Heerden, P.D.R. (1979). Die effek van rooibostee op ysterabsorpsie. *South African Medical Journal*, 55, 631-632.
Hölsgens, R., Wascher, E., Bauer, C., Boll, J., Bund, S., Dankwart-Kammoun, S., Heese, I., Schrot, K., Schultze, J., & Tenambergen R. (2023). Transdisciplinary Research along the Logic of Empowerment: Perspectives from Four Urban and Regional *Transformation Projects. Sustainability*, 15(5):4599. https://doi.org/10.3390/su15054599
Jantsch, E. (1970). Inter- and Transdisciplinary University: a systems approach to education and innovation. *Policy Science*, 1(1), 403-28. doi: 10.1007/BF00145222.
Joubert, E., Gelderblom, W.C.A., Louw, A., de Beer, D., 2008. South African herbal teas: Aspalathus linearis, Cyclopia spp. and Athrixia phylicoides – a review. *Journal of Ethnopharmacology*, 119, 376–412.
Joubert, E., Schulz, H., 2006. Production and quality aspects of rooibos tea and related products. A review. The *Journal of Applied Botany and Food Quality*, 80, 138–144.
Joubert, E., & de Beer, D. (2011). Rooibos (Aspalathus linearis) beyond the farm gate: From herbal tea to potential phytopharmaceutical. *South African Journal of Botany*, 77, 869–886. doi:10.1016/j.sajb.2011.07.004
Kamati, O.V., Davies, S.E.H., Marnewick, J.L. (2020): *Effect of dietary rooibos on exercise-induced oxidative stress, performance and recovery*. CPUT Post Graduate Conference.
Kamati, O.V., Davies, S.E.H, Marnewick J, Sheik N and Bester D (2021). Effect of dietary rooibos on exercise-induced oxidative stress, performance, and recovery. PAMGS and Free Radical Research Africa Conference (Virtual), 15-16 September 2021.
Kamati OV, Marnewick, J.M., Davies, S.E.H., and Louw, R. (2022a). *Investigating the Association between exercise-induced pro-inflammatory response and genetic individuality*: Applied Microbial and Health Biotechnology Institute (AMHBI) symposium, Cape Peninsula University of Technology, Cape Town, South Africa, 7 September 2022.
Kamati, O.V., Marnewick, J.M., Davies, S.E.H., and Lowe, R. (2022b). *Rooibos, a potential oxidative stress modulator and ergogenic aid*. CPUT postgraduate conference.
Kayser, O. (2018). Ethnobotany and Medicinal Plant Biotechnology: From Tradition to Modern Aspects of Drug Development. *Planta Medica*, 84(12/13), 834-838. DOI: 10.1055/a-0631-3876
Kerksick, C.M., Wilborn, C.D., Roberts, M.D., Smith-Ryan, A., Kleiner, S.M., Jager, R., Collins, R., Cooke, M., Davis, J.N, Galvan, E., Greenwood, M., Lowery, L.M., Wildman, R., Antonio, J., & Kreider, R.B. (2018). ISSN exercise & sports nutrition review update: research & recommendations. *Journal of the International Society of Sports Nutrition*, 15(1), 38.
Kettunen, J., Tukiainen, T., Sarin, A.P., Ortega-Alonso, A., Tikkanen, E., Lyytikainen, L.P., et al. (2012). Genome-wide association study identifies multiple loci influencing human serum metabolite levels. *Nature Genetics*, 44, 269–76.
Knapik, JJ, R.A., Steelman, S.S., Hoedebecke, K.G., Austin, E.K., Farina, H.R., Lieberman. (2016). Prevalence of dietary supplement use by athletes: systematic review and meta-analysis. *Sports Medicine*, 46(1), 103–123.
Koeppen, B.H., & Roux, D.G. (1965). Aspalathin: a novel C-glycosylflavonoid from Aspalathus linearis. *Tetrahedron Letters*, 3497–3503.
Inanami, O. Asanuma, T., Inukai, N., Jin, T., Shimokawa, S., Kasai, N., Nakano, M., Sato, F., Kuwabara, M. (1995). The suppression of age-related accumulation of lipid peroxides in rat brain by administration of Rooibos tea (Aspalathus linearis). *Neuroscience Letters*, 196, 85-88.
Lafay, S., Jan, C., Nardon, K., Lemaire, B., Ibarra, A., Roller, M., Houvenaeghel, M., Juhel, C. and Cara, L. (2009). 'Grape extract improves antioxidant status and physical performance in elite male athletes'. *The Journal of Sports Science and Medicine*, 8(3), 468–480.
Lang, D.J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., and Thomas, C.J. (2012). Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainable Science*. 7, 25–43. https://doi.org/10.1007/s11625-011-0149-x.
Lawrence, M.G., Williams, S., Nanz, P., and Renn, O. (2022). Characteristics, potentials, and challenges of transdisciplinary research. *One Earth*, 5(1), 44-61. https://doi.org/10.1016/j.oneear.2021.12.010

Lightsey, D.M., & Attaway, J.R. (1992). Deceptive tactics used in marketing purported ergogenic aids. *Journal National Strength and Conditioning Association*, 14(2), 26-31.
Linder, H.P. (2003) The radiation of the Cape flora, southern Africa. Biological Reviews, 78, 597–638.
Londe, A. M., Marocolo, M., Marocolo, I. C., Fisher, J., Neto, O. B., Souza, M. V. C., et al. (2018). Wearing colored glasses can influence exercise performance and testosterone concentration? *Sports Medicine International*. Open 02, E46–E51. doi: 10.1055/a-0601-7250
Lozano, R. (2006), "Incorporation and institutionalization of SD into universities: breaking though barriers to change", *Journal of Cleaner Production*, 14(9/11), 787-796.
Madsen, R., Lundstedt, T., & Trygg, J. (2010). Chemometrics in metabolomics–a review in human disease diagnosis. *Analytica Chimica Acta*, 659, 23–33.
Manning, J., & Goldblatt, P. (2012). *Plants of the Great Cape Floristic Region* 1: The Core Cape Flora, Strelitzia 29. South African National Biodiversity Institute, Pretoria.
Marnewick, J.L., Gelderblom, W.C.A., & Joubert, E. (2000). An investigation on the antimutagenic properties of South African herbal teas. *Mutation Research*, 471,157–166.
Marnewick, J.L. (2004). *Chemopreventive properties of two South African herbal teas, rooibos tea (Aspalathus linearis) and honeybush tea (Cyclopia intermedia) utilizing different short-term in vivo and in vitro carcinogenesis models.* Ph.D. (Biochemistry) Dissertation. University of Stellenbosch, Stellenbosch, South Africa.
Marnewick, J.L., Joubert, E., Joseph, S., Swanevelder, S., Swart, P., & Gelderblom,W.C.A. (2005). Inhibition of tumour promotion in mouse skin by extracts of rooibos (Aspalathus linearis) and honeybush (Cyclopia intermedia), unique South African herbal teas. *Cancer Letters*, 224, 193–202.
Marnewick, J. L. (2009). *Rooibos and Honeybush: recent advances in chemistry, biological activity and pharmacognosy*. (In H. Juliani, et al. (Eds.): African Natural Plant Products: New Discoveries and Challenges in Chemistry and Quality;.; ACS Symposium Series; American Chemical Society: Washington, DC, 2010. p. 277-280).
Marnewick, J.L., Rutenbach, F., Venter, I., Neethling, H., Blackhurst, D.M., Wolmarans, P., & Macharia, M. (2011). Effects of rooibos (Aspalathus linearis) on oxidative stress and biochemical parameter in adults at risk for cardiovascular disease. *Journal of Ethnopharmacology*, 133, 46-52.
Marocolo, M., Billaut, F., & da Mota, G. R. (2018). Ischemic preconditioning and exercise performance: an ergogenic aid for whom? *Frontiers in Physiology*, 9, 1874. doi: 10.3389/fphys.2018.0 1874
Marocolo, M., Simim, M. A. M., Bernardino, A., Monteiro, I. R., Patterson, S. D., & da Mota, G. R. (2019). Ischemic preconditioning and exercise performance: shedding light through smallest worthwhile change. *European Journal of Applied Physiology*, 119, 2123–2149. doi: 10.1007/s00421-019-04 214-6
Maughan RJ. (1999). Nutritional ergogenic aids and exercise performance. *Nutrition Research Reviewer*,12:233280.
Mayer J., & Bullen B. (1960). *Nutrition and athletic performance. Physiological Reviews*, 40, 369-397.
Moreno, B., Veiga, S., Sánchez-Oliver, A.J., Domínguez, R., & Morencos, E. (2022). Analysis of Sport Supplement Consumption by Competitive Swimmers According to Sex and Competitive Level. *Nutrients*, 14, 3218. https://doi.org/ 10.3390/nu14153218
Morton, J.F. (1983). Rooibos tea, aspalathus linearis, a caffeineless, low-tannin beverage. *Economic Botony*, 37(2), 164–173. https://doi.org/10.1007/BF02858780
Mota, G.R., and Marocolo, M. (2022). Editorial: Ergogenic Aids: Physiological and Performance Responses. *Frontiers in Sports and Active Living*, 4:902024.doi: 10.3389/fspor.2022.902024
Nagoya protocol. (2010). Available from: https://www.cbd.int/abs/doc/protocol/nagoya-protocol-en. pdf [accessed Sep 16 2022].
Nicolescu, B. (1985). Nous, la particule et le monde [*We, the particle and the world*]. Paris, France: Le Mail.
Nicolescu, B. (2002). *Manifesto of transdisciplinarity* [Trans. K-C. Voss]. New York, NY: SUNY.
Nicolescu, B. (2012). 'The need for transdisciplinarity in higher education in a globalized world', *Transdisciplinary Journal of Engineering & Science*, 3, 11–18.

Nowotny, H. (2003). '*The potential of transdisciplinarity'*, in Rethinking interdisciplinarity, interdisciplines project. https://www.worldfishcenter.org/sites/ default/files/The%20potential%20for%20transdisciplinarity.pdf
National Inquiry Services Centre (NISC)(2023).
https://www.nisc.co.za/products/101/books/a-contribution-to-the-south-african-materia-medica#
National environmental management biodiversity act (NEMBA)(2004). 2004 [cited Sep 17 2022]. Available from: https://www.environment.gov.za/sites/default/files/legislations/nema_amen dment_act10.pdf.
Ng, S.B., Turner, E.H., Robertson, P.D., Flygare, S.D., Bigham, A.W., Lee, C., et al. (2009). Targeted capture and massively parallel sequencing of 12 human exomes. *Nature*, 461, 272–6. (7261):272-6. doi: 10.1038/nature08250.
Packer, L. (1997) 'Oxidants, antioxidant nutrients and the athlete'. Journal of Sports Sciences, 15(3), 353–363.
Pantsi, W.G., Marnewick, J.L., Esterhuyse, A.J., Rautenbach, F., & van Rooyen, J. (2011). Rooibos (*Aspalathus linearis*) offers cardiac protection against ischaemia/ reperfusion in the isolated perfused rat heart. *Phytomedicine*, 18, 1220 1228. doi:10.1016/j.phymed.2011.09.069
Pappe, L. (1868). Florae Capensis Medicae Prodromus, Or, *An Enumeration Of South African Indigenous Plants Used As Remedies By The Colonists Of The Cape Of Good Hope*, Publisher A. S. Robertson.
Patti, G.J., Yanes, O., & Siuzdak, G. (2012). Innovation: Metabolomics: the apogee of the omics trilogy. *Nature Reviews Molecular Cell Biology*, 13, 263–9.
Pennington, D., Ebert-Uphoff, I., Freed, N., Martin, J., & Pierce, S. A. (2020). Bridging sustainability science, earth science, and data science through interdisciplinary education. *Sustainability Science,* 15, 647–661.
Piaget J. (1972). *The epistemology of interdisciplinary relationships*. In: Apostel L, editor. Interdisciplinarity: problems of teaching and research in universities. Paris: Organization for Economic Co-operation and Development (OECD); (pp.127-39).
Reed J.D. (1977). They hunger for success. *Sports Illustrated*, 46, 65-68 (February 28).
Reid, W.V., Sittenfeld, A., Laird, S.A., Janzen, D.H., Meyer, C.A., Gollin, M.A., Gamez, R., & Juma, C. (1993). BIODIVERSITY PROSPECTING: *Using Genetic Resources for Sustainable Development*. World Resources Institute (WRI), USA Instituto Nacional de Biodiversidad (INBio), Costa Rica Rainforest Alliance, USA; African Centre for Technology Studies (ACTS), Kenya. A Contribution to the: WRI/IUCN/UNEP Global Biodiversity Strategy May 1993, Copyright © 1993 World Resources Institute. All rights reserved. ISBN 0-915825-89-9
Richardson, D.P. (1996). Functional foods–shades of gray: an industry perspective, *Nutrition Reviews*, 11(2), S174–185.
Rinschen, M.M., Ivanisevic, J., Giera, M., & Siuzdak, G. (2019). Identification of bioactive metabolites using activity metabolomics. *Nature Reviews Molecular Cell Biology*, 20, 353–367.
Roberfroid, M.B. (1997). Health benefits of non-digestible oligosaccharides. *Advances in Experimental Medicine and Biology*, 427, 211–219.
Rong, Y., Geng, Z., & Lau, B.H. (1996). 'Ginkgo biloba attenuates oxidative stress in macrophages and endothelial cells'. *Free Radical Biology and Medicine*, 20(1), 121–127.
Rosenfield, P.L. (1992). The potential for transdisciplinary research for sustaining and extending linkages between the health and social sciences. *Social Science & Medicine,* 35(11), 1343–57.
South African Rooibos Council (SARC)(2022). *Khoi and San to share in benefits of rooibos*; 2022 [cited Sep 26 2022]. Available from: https://sarooibos.co.za/khoi-and-san-to-share-in-benefits-of-rooibos/.
South African Rooibos Council (SARC)(2023). https://southafrica.co.za/south-african-rooibos-council.html
Sasaki, Y.F., Yamada, H., Shimoi, K., Kator, K., & Kinae, N. (1993). The clastogen-suppressing effects of green tea, Po-lei tea and Rooibos tea in CHO cells and mice. *Mutation Research,* 286, 221-232.
Schapera, I. (1930). *The Khoisan Peoples of South Africa. Bushmen and Hottentots*. Routledge and Kegan Paul Ltd, London.
Schroeder, D., Chennells, R., Louw, C., Snyders, L., & Hodges, T. (2020). The Rooibos Benefit Sharing Agreement–Breaking New Ground with Respect, Honesty, Fairness, and Care. *Cambridge Quarterly of Healthcare Ethics*, 29(2), 285-301. doi: 10.1017/S0963180119001075, PMID 31685054.

Scott, G., Tilbury, D., Deane, L. & Sharp, L. (2012). *Turnaround Leadership for Sustainability in Higher Education*, Australian Government, Office for Learning and Teaching Canberra.
Shimamura, N., Miyase, T., Umehara, K., Warashina, T., & Fujii, S. (2006). Phytoestrogens from Aspalathus linearis. *Biological and Pharmaceutical Bulletin*, 29, 1271-1274.
Shin, S.Y., Fauman, E.B., Petersen, A.K., Krumsiek, J., Santos, R., Huang, J., et al. (2014). An atlas of genetic influences on human blood metabolites. *Nature Genetics*, 46, 543–50.
Smith, A. (2011). *A contribution to the South African Materia Medica Publishers*: Cory Library, Rhodes University as part of the Eastern Cape Reprints series. ISBN 13: 978-0-86810-469-0
Smyth, T.S. (2017). Transdisciplinary Pedagogy: A Competency Based Approach for Teachers and Students to Promote Global Sustainability. *Journal of Interdisciplinary Studies in Education,* 5(2), 64-72.
Snykers, F.O., & Salemi, G. J. (1974). *Studies of South African medicinal plants. Part I. Quercetin as the major in vitro active compound of rooibos tea*. South African Chemical. Institute, 27, 5-7.
Tanaka, M., Wang, G., & Pitsiladis, Y.P. (2016). Advancing sports and exercise genomics: moving from hypothesis-driven single study approaches to large multi-omics collaborative science. *Physiological Genomics*, 48, 173–174.doi:10.1152/physiolgenomics.00009.2016.
Thunberg, C.P. (1986). *Travels at the Cape of Good Hope, 1772–1775*: based on the English edition, London 1793–1795, edited by Emeritus Prof. Vernon Siegfried Forbes, translation from the Swedish revised by J. & I. Rudner, Cape Town: Van Riebeck Society, xlviii–366 p. (p. 44).
Tucker, R., & Collins, M. (2012). What makes champions? A review of the relative contribution of genes and training to sporting success. *British Journal of Sports Medicine*, 46, 555–561.
Van der Bijl-Brouwer, M, Kligyte, G. & Key, T. (2021). A Co-evolutionary, Transdisciplinary Approach to Innovation in Complex Contexts: Improving University Well-Being, a Case Study. She Ji: The Journal of Design, Economics, and Innovation, 7(4), 565-588, ISSN 2405-8726, https://doi.org/10.1016/j.sheji.2021.10.004.
Van Itallie, T.B., Sinisterra, L., & Stare F.J. (1956). Nutrition and athletic performance. *Journal of the American Medical Association*, 162, 1120-1126.
Van Wyk, B-E., Van Oudtshoorn, B., & Gericke, N. (1997). In *Medicinal Plants of South Africa*. Briza Publications, Pretoria, South Africa, 1997; pp. 290.
Voight, B.F., Kang, H.M., Ding, J., Palmer, C.D., Sidore, C., Chines, P.S., et al. (2012). The metabochip, a custom genotyping array for genetic studies of metabolic, cardiovascular, and anthropometric traits. *PLoS Genetics*, 8, e1002793.
Walton, E., & Engelbrecht, P. (2022). Inclusive education in South Africa: path dependencies and emergences, *International Journal of Inclusive Education*. http://doi:10.1080/13603116.2022.2061608
Wackerhage, H., Miah, A., Harris, R.C., Montgomery, H.E., & Williams, A.G. (2009). Genetic research and testing in sport and exercise science: A review of the issues. Journal of Sports Science, 27, 1109–1116.
Wang, W.Y., Barratt, B.J., Clayton, D.G.,& Todd, J.A. (2005). Genome-wide association studies: theoretical and practical concerns. *Nature Reviews Genetics*, 6, 109–18.
Williams, M.H. (1989). Nutritional ergogenic aids and athletic performance. *Nutrition Today*, 24, 7-14.
Williams, C. (1998). *Diet and sports performance*. In Oxford Textbook of Sport Medicine, 2nd ed., [M Harries, C Williams, WD Stanish and LL Micheli, editors]. New York: Oxford University Press, 1998, (pp. 77–97).
World Health Organization (WHO)(2013). WHO *Traditional Medicine Strategy*: 2014–2023. Geneva, Switzerland: WHO Press; 2013
Wynberg, R. (2017). Making sense of access and benefit sharing in the rooibos industry: towards a holistic, just and sustainable framing. *South African Journal of Botony*, 110, 39-51. doi: 10.1016/j.sajb.2016.09.015.
Yoshikawa, T., Natio, Y., Oyamada, H., Ueda, S., Tangigawa, T., Takemura, T., Sugino, S., & Kondo, M. (1990). Scavenging effects of Aspalathus linearis (rooibos tea) on active oxygen species. *Advances in Experimental Medicine and Biology*, 264, 171–174.
Zhang, X. (**2002**). World Health Organization. WHO *Traditional Medicine Strategy*, Geneva, (pp. 2002–2005).