AIS SPORTS SUPPLEMENT FRAMEWORK
ABCD CLASSIFICATION SYSTEM

BRANCHED-CHAIN AMINO ACIDS (BCAA)

SUMMARY REPORT: CONSIDERATION FOR CLASSIFICATION OF A SUPPLEMENT INGREDIENT

The ABCD Classification system ranks sports foods and supplement ingredients into four groups according to scientific evidence and other practical considerations that determine whether a product is safe, permitted, and effective in improving sports performance. The classification of supplements and sports foods is made via the consideration of the AIS Sports Supplement Framework Committee and evolves according to new knowledge plus the informed direction of our key stakeholders. This report summarises decisions made regarding the addition or reclassification of a substance within the System, based on evidence provided by the applicant and assessed (and potentially augmented) by the Framework Committee.

SUMMARY REPORT FOLLOWING CONSIDERATION OF ADDITION/ALTERATION OF SUPPLEMENT INGREDIENT	
Name/ Formulation & description	Branched chain amino acids (BCAA i.e. leucine, isoluceine and valine usually in a 2:1:1 ratio) and leucine in isolation are purified amino acids appearing as crystalline powders. They are poorly soluble in water and bitter tasting. The sources of the protein from which BCAA/ LEU are derived from are not immediately apparent on the packaging of many products. However, there are several sources[1]: 1. Purified from processed animal feathers/fur/hair/skin 2. Purified from processed plant proteins 3. Fermented by genetically modified micro-organisms engineered to ferment sugar to the amino acids in question. There is some concern that they may also be derived from human hair.[1]
Current AIS Supplement Framework Classification	Group B
Agreed AIS Supplement Framework Classification	Group C
Proposed benefit[s]	1. Enhanced endurance capacity/reduced fatigue 2. Improved recovery following muscle damage (reduced soreness/damage) 3. Increased muscle mass via activating muscle protein synthesis
Proposed mechanism of action[s]	BCAAs are essential amino acids metabolised primarily within the skeletal muscle and they play an important role in both cellular energy homeostasis[2] and in the regulation of muscle protein synthesis.[3] Theoretically, by supporting energy metabolism and by stimulating muscle protein synthesis it is suggested that BCAA/ leucine may support muscle growth. Furthermore, there is some evidence that BCAA/leucine supplementation may assist in the recovery from muscle damaging exercise via similar mechanisms to those described above. Finally, BCAA supplementation may provide substrate to working muscle under glycogen depleted conditions and due to BCAA competition for transport into the brain with tryptophan, BCAA supplementation may limit tryptophan entry into the brain. Theoretically this would reduce serotonin production in the brain and limit the onset of fatigue.[4]

Summary of supporting evidence	The evidence for BCAA/leucine supplementation supporting endurance performance is equivocal.[4] A recent study[5] suggests that 20 g of BCAA ingested 1hr prior to a ramp test on a treadmill can delay fatigue. However, like much of the BCAA literature around endurance performance/fatigue there are significant flaws in the research. In the case of[5] the placebo is not matched for calories. A thorough analysis of the most recent research on BCAA and endurance performance is needed to determine their efficacy for promoting performance. There is a great deal of heterogeneity in the literature around supplementation protocols and dosing strategies and so firm recommendations on this are difficult. There is an argument however, that because BCAAs become significant substrates during prolonged exercise that supplementing may prevent muscle damage/breakdown, but there is little evidence to support this notion. For instance, 20 g of BCAA supplemented before and during a 100 km race (3 g 1hr before followed by 17 g throughout a 100 km race) did not affect performance or markers of muscle damage.[6] There is building evidence for BCAA supplementation to augment the response to damaging exercise. A meta-analysis of the literature from 2007-2013 suggests that BCAA supplementation may significantly reduce the severity of delayed onset muscle soreness following damaging exercise when compared to placebo treatments.[7] Additionally, a systematic literature review carried out on research published up to August 2017 suggests that there may be a modest benefit of BCAA supplementation for markers of muscle damage.[8] In an analysis of the dosing strategies in this systematic review[8] it is suggested that a daily intake greater than 200 mg·kg·day-1 (~16 g) for at least 7 days prior to the damaging exercise may alleviate some of the impacts of muscle damage on muscle performance (force decrement, plasma CK). However, it should be noted that the placebo in all the included trials is devoid of any protein. So, it remains to be seen if BCAA supplementation would be better/worse than intact protein for this outcome measure. Furthermore, the systematic review suggests efficacy of BCAA supplementation only if the damage is low-moderate. Because BCAA/leucine are critical for signalling to increase muscle protein synthesis[3], it has long been thought that BCAA/leucine supplementation may enhance muscle protein synthesis and therefore growth in response to nutrition/exercise. However, the case for supplementing BCAA/leucine in isolation seems to be weak at best. For instance, when 5.6 g (equivalent content in 20 g of Whey) of BCAA were supplemented following a session of resistance exercise the resulting increase in muscle protein synthesis was only 22%.[8] With intact protein we would expect this stimulatory response on muscle protein synthesis to be at least double that. So, whilst BCAAs, when taken in isolation following resistance exercise, can stimulate muscle protein synthesis they probably should not be recommended over whole foods containing sufficient high-quality protein. However, there may be a case for utilising BCAA/leucine to "top up" the anabolic potential of sub-optimal meals. The leucine content of a meal seems to be the key driver of the anabolic response (muscle protein synthesis) to that meal. Approximately 2.5 g of leucine per meal (equivalent to ~20 g of whey protein) seems to be sufficient to maximise muscle protein synthesis.[3] Furthermore, when a suboptimal dose of whey protein (6.25 g whey, 0.75 g of leucine) in a mixed macronutrient beverage is "topped up" with leucine to contain 3 g of leucine, it produces a similar muscle protein synthesis response in the recovery from resistance exercise as 25 g of whey protein (3g of leucine).[9] These data suggest that leucine could be used to enhance the anabolic potential of certain meals that may not, on their own, maximise muscle protein synthesis. This could take the form of supplementing sub-optimal meals (plant-based meals, meals with less than 20-30 g of high-quality protein) with up to 3 g of additional leucine. However, we do not know if this strategy would support muscle growth in the long term.
Limitations to current science	**Endurance performance:** The evidence on the role of BCAA/leucine in supporting endurance performance or preventing damage from long duration activity is very heterogeneous and equivocal. From the literature so far, a clear dosing strategy cannot reliably be suggested especially considering that the placebo is often not optimal for assessing outcomes. There is probably room in the literature for a systematic review/meta-analysis to address this aspect of BCAA/Leucine supplementation. **Muscle damage recovery:** The evidence for BCAA supplementation in reducing the severity of symptoms following muscle damage protocols (drop jumps, repeated eccentric contractions) is building. But the benefits appear to be marginal and given that the placebo is often simply a calorically matched product devoid of protein it would be hard to argue for the supplementation protocol to be implemented in place of a sound diet with sufficient high quality protein. Furthermore, the supplementation protocols that seem to be effective (when compared against placebos containing no protein) are likely impractical given the large daily doses required (16-20 g). **Muscle anabolism:** Where intact and high-quality protein can be consumed in sufficient quantities to maximise muscle anabolism there appears to be little-no need to supplement with BCAA/Leucine. However, where a meal is going to be sub-optimal for maximising muscle anabolism (plant based protein or less than 20-30 g of high quality protein) then there may be a benefit to supplementing that meal with leucine up to a total of 2.5-3 g of leucine. It should be noted that the "benefit" in this instance is purely for muscle protein synthesis and there is not yet firm evidence of this kind of dosing strategy augmenting other outcomes such as muscle growth, strength, or recovery in athletic populations.
Final consensus	While there is some evidence supporting the claims that BCAA/leucine supplementation favourably influences skeletal muscle protein metabolism, efficacy is significantly less than acute ingestion of high biological value proteins. As such, these more efficacious interventions should be prioritised over BCAA/leucine. The fortification of lower biological value proteins with additional BCAA/leucine to optimise muscle anabolism is recognised and discussed in a separate fact sheet on isolated protein supplements.

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The Australian Institute of Sport (AIS) Supplement Framework is an initiative of the Australian High Performance Sport System. The AIS acknowledges the support of members of the National Institute Network (NIN) and National Sporting Organisations (NSO) and their staff in delivering content expertise. This information is intended to help athletes, coaches and scientists make evidence-based decisions about the use of supplements and sports foods. Before engaging in supplement use, we recommend that each individual refer to the specific supplement policies of their sporting organisation, sports institute or parent body, and seek appropriate professional advice from an accredited sports dietitian (**www.sportsdietitians.com.au**).

Athletes should be aware that the use of supplements may have doping implications. Athletes are reminded that they are responsible for all substances that enter their body under the 'strict liability' rules of the World Anti-Doping Code. Some supplements are riskier than others. The Sport Integrity Australia (SIA) app is a useful resource to help mitigate the risk of inadvertent doping by helping to identify supplements that have been batch-tested. The SIA App provides a list of more than 11,000 batch-tested products. We recommend that all athletes consult the educational resources of SIA regarding the risks associated with supplements and sports foods.. While batch-tested products have the lowest risk of a product containing prohibited substances, they cannot offer you a guarantee that they are not contaminated (**www.sportintegrity.gov.au/what-we-do/supplements-sport**).

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