History of Red Bull

Since its first appearance in Austria in 1984, Red Bull has gained popularity throughout Europe and North America. The idea of an energy drink appealed to people and it became a widely consumed beverage. The Red Bull Company states that drinking Red Bull increases physical endurance, concentration, reaction speed and emotional status (1). The major ingredients of Red Bull are sugar, taurine, glucuronolactone, and caffeine. While Red Bull has been in the market since 1984, no conclusive evidence exists to validate its proposed effects.

While Red bull is composed of many different ingredients, the two compounds showcased as the key components responsible for Red Bull's proposed effects are taurine (1000 mg) and glucruonolactone (600 mg). Unlike the popular myth that taurine is an extract from a bull's testicles, taurine (2-aminoethanesulphonic acid) is an amino acid naturally found throughout the body (2). Produced in the liver and the brain, taurine plays an important role in osmolarity regulation, muscle contraction and neuroprotection (3). Glucuronolactone is also a naturally found compound in the body but little is known about its effects. The manufacturers claim that glucuronolactone is involved in a detoxification process; however, no definitive study has been done to validate this claim. When confronted, the representatives of the Red Bull Company could not quote any credible source for their claim and were not knowledgeable about the actions and side effects of glucuronolactone (4).

Effects of Taurine on Muscle

Taurine is found in high concentrations in skeletal muscles and plays an important role in modulating contractile function (5). Taurine increases force generation by enhancing Sarcoplasmic Reticulum's Ca^{2+} accumulation and release (5). Increasing taurine levels also augments the mean rate of increase in the force response. It is suggested that balancing the endogenous taurine concentrations is crucial for maintaining the appropriate force output during muscle contraction. Muscle fibers possibly modulate their contractility by increasing or decreasing the intracellular taurine levels in response to neuronal inputs (5).

From examining taurine's role in muscle contraction, it may seem possible that increasing the body's taurine concentration through dietary intake, e.g. Red Bull consumption, can enhance force generation. However, no definitive study exists on the absorption rate of taurine following dietary ingestion and/or incorporation rate into muscle cells. Furthermore, considering that the intracellular taurine concentration is critically regulated, it seems unlikely that an increase in plasma level of taurine following taurine consumption would greatly perturb this closely regulated balance.

Taurine and Caffeine

In a study by Baum and WeiB, the effects of taurine and caffeine in young athletes were examined. Cardiac parameters from three different groups were measured after an exercise. Prior to the exercise the investigators gave the first group Red Bull, the second group an analogous energy drink without taurine, and the third group a similar drink lacking both taurine and caffeine. The results reported significant increases in stroke volume and diastolic inflow velocity only in the Red Bull group. This led to the hypothesis that the combinatorial effect of both taurine and caffeine achieved from drinking Red Bull enhance the ventricular functions (6).

However, the study design of this experiment must be re-examined for several reasons. First, only 12 subjects participated in the study, raising concerns that the sample size may be too small to draw any definitive conclusions. Second, the preparation of the three types of drinks was not fully controlled by the researchers. The study coordinators state that the three samples were directly provided by the Red Bull Company (6). Such close involvement by the manufacturers undermines objectivity and may increase the possibility of bias that would obscure the results. Third, in one experiment a placebo group that did not ingest caffeine surprisingly revealed a significantly higher diastolic inflow velocity than in the group that took caffeine (6). This unexpected result is anomalous since caffeine is widely known to increase overall cardiovascular function and would have been expected to raise the inflow velocity. Such observed discrepancies must be accounted for if the combinatorial effects of taurine and caffeine on ventricular function are indeed the sole agents of the purported enhancements.

Caffeine

It seems more plausible that any muscular function enhancement from Red Bull is derived from its caffeine content. Numerous studies have shown caffeine to have an ionotropic effect on the body and improve one's endurance (7,8). Due to such effects, the IOC (International Olympics Committee) ban caffeine concentrations higher than 12 mg/mL (8). Studies show that caffeine ingestion results in an increase in epinephrine, plasma lactate, and cortisol levels (7). Plasma beta-endorphin levels almost double in some studies following caffeine intake (7). The molecular mechanism of caffeine involves blockage of adrenergic receptors leading to an increase in cAMP concentration and inhibition of cAMP catabolism (8). Thus it can be concluded that caffeine is an ergogenic aid that stimulates muscular performance, and may well be the only active compound in Red Bull to produce the supposed invigorating sensations.

Effects of Taurine on the Neural System.

Taurine is present in high concentrations throughout the brain and plays an important role both in neuroprotection and enhancement of neurotransmission (2). It is hypothesized that ingesting taurine along with caffeine enhances one's concentration and reaction speed while improving emotional status. Many experiments were performed to test these proposed effects of taurine and caffeine. However, none of the studies clearly demonstrated that taurine and caffeine have combinatorial effects on cognitive performance.

Seidl et al. performed a double-blinded, placebo-controlled study with the experimental group ingesting a capsule containing caffeine, taurine and glucuronolactone while the control group received receiving a placebo capsule. The authors reported that the experimental group had shorter motor reaction times and scored better when their emotional well-being was evaluated (9). Thus they concluded that taurine in conjunction with caffeine and glucuronolactone had positive effects on cognitive function. They suggested that taurine may be involved in interactions with GABAergic, glycinergic, cholinergic and adrenergic neurotransmitter system. However, they agreed upon the possibility that these findings on cognitive performance increases may have been due to caffeine. In a different study, Alford et al. compared the effects of Red Bull with

carbonated mineral water as a placebo-control and reported that the experimental group showed increased subjective alertness, concentration, and physical endurance (10). However, they also noted that the improvements in cognitive functions were similar to those observed in a caffeine study. Another work by Warburton et al. reported improved information processing in individuals who consumed caffeinated taurine drinks than in those who took placebo drinks (11). The authors proposed that taurine may modulate the effects of caffeine and may influence mood states, but no evidence was provided for this hypothesis.

None of the experiments tested the possibility that caffeine alone could have produced such results. It is widely known that caffeine blocks adenosine receptors and thereby increases cAMP concentration (8). This blockade can free cholinergic neurons from inhibitory control, leading to pervasive excitatory responses (7). These properties of caffeine alone may explain the favorable cognitive influences seen in the experiments.

Blood Brain Barrier

Taurine is abundantly found in the brain and is known to exert neuroprotective effects against excitotoxic agents and oxidative stress, such as those released during an ischemic episode (3). An *in vivo* analysis indicated that during ischemia, a 17-fold increase in taurine levels can be observed within the brain (3). There are two sources of taurine in the brain: direct synthesis from neurons and transport across the Blood-Brain Barrier.

The Blood-Brain Barrier (BBB) is a membranous barrier surrounding blood vessels that lead to the brain and regulates the exchange of molecules between the blood and the brain (12). The BBB is highly permeable to non-polar compounds and less permeable to polar compounds. Such closely monitored regulation prevents harmful substances from entering the brain and only permits the passage of substances necessary for the brain. Studies with rat brain indicate that sodium and chloride dependent taurine transporters exist in the BBB (12). The activity of these transporters is tightly regulated by transcription of the genes encoding them. This transcription seems to be dependent on the degree of cell damage, osmolality and taurine in the brain, suggesting that active expression of this gene is an acute response to neuronal crisis (3).

It can be deduced that under normal non-ischemic conditions, taurine levels within the brain are maintained at a stable level. Therefore, an increase in the taurine plasma level resulting from dietary supplementation is unlikely to cause a sudden influx of taurine into the brain. Furthermore, considering the substantial amount of indigenous taurine already present in the brain, it is questionable whether any entry would make a significant difference to the total concentration. While caffeine can readily diffuse across the BBB, the entry of taurine seems to be regulated with more stringent control.

Conclusion

The Red Bull Company claims that drinking Red Bull improves one's cognitive capabilities and muscular performance (1). The company attributes these enhancements to the unique combination of the ingredients including key components such as caffeine, taurine and glucuronolactone. However, it seems more plausible that most of the effects observed when drinking Red Bull come principally from caffeine. Red bull contains about the same amount of caffeine (80 mg) as a cup of coffee. However, because coffee takes time to cool, it is ingested over a longer period of time than it takes to consume Red Bull. Drinking Red Bull brings into the body a large dose of caffeine in a short amount of time, resulting in a sharp rise of plasma caffeine concentration. In addition, a psychosomatic placebo effect of having consumed an "energy drink" may compound the chemical's actual effects. Thus it seems that drinking a cold cup of coffee may induce the same "energizing and refreshing" effects of drinking Red Bull – and best of all, at one-third the cost.

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