



# Cashew Apple Juice: Contents and Effects on Health



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## Abstract

In this review, three components of cashew apple juice (CAJ) including vitamin C, branched-chain amino acids (BCAAs), and anacardic acids are considered to play major roles on metabolism, oxidative stress, immune function, and cardiac autonomic function in exercise. Supplementation with CAJ could promote effects of exercise training on increased fat utilization, increased immune cell counts, increased vagal activity, and decreased oxidative stress during high-intensity exercise in healthy persons. This may lead to increase endurance time in exercise and may help athletes and sedentary persons to early recover and reduce susceptibility to involve in illness after the competition or high-intensity exercise session.

**Keywords:** Vitamin C; Branched-chain amino acids; Anacardic acids; Metabolism; Oxidative stress; Cardiac autonomic function; Immune function

**Abbreviations:** BCAAs: Branched-Chain Amino Acids; CAJ: Cashew Apple Juice; CHF: Chronic Heart Failure; ROS: Reactive Oxygen Species

## Introduction

The cashew tree (*Anacardium occidentale L.*) belongs to the family Anacardiaceae. It is a native plant of Brazil. The fruit consists of a cashew nut (the true fruit) and a cashew apple (*pseudofruit*). The cashew nut is the most important product of the cashew tree; whereas the cashew apple has increased in value [1]. Many procedures have been industrialized for transforming the cashew apple into several products such as juice, jam, syrup, chutney, and beverage [2]. Cashew apple juice (CAJ) is one of the most popular juices in Brazil and is widely available in the Brazilian market [3].

## Contents of Cashew Apple Juice

CAJ is an excellent source of vitamin C, averaging 200-269mg/100g of juice, 4-7 times higher than orange juice [4]. In addition, the CAJ also contains a complex mixture of vitamins, antioxidants, fructose and glucose, mineral salts, organic acids, amino acids, anacardic acids, and carotenoids such as  $\alpha$ -carotene,  $\beta$ -carotene and  $\beta$ -cryptoxanthin [5,6].

## Cashew Apple Juice and Fat Utilization

Oxidation rates of muscle glycogen and plasma glucose increased and plasma free fatty acids and triacylglycerol decreased during high-intensity exercise [7]. Our previous study demonstrated that supplementation with CAJ at 3.5ml/

kg body mass/day for 4 weeks enhanced fat oxidation during high-intensity exercise and increased endurance performance in athletes and sedentary persons [8]. CAJ may enhance fat oxidation via the effect of vitamin C on carnitine synthesis [9]. Vitamin C acts as a cofactor for  $\epsilon$ -N-trimethyl-L-lysine hydroxylase and  $\gamma$ -butyrobetaine hydroxylase enzymes. They are required for the biosynthesis of carnitine which plays an important role on fat oxidation in skeletal muscle [10]. Moreover, vitamin C also directly stimulates the  $\beta$ -oxidation of fatty acids [11]. Leucine, the other content, was suggested to take synergistic effects on energy metabolism. It induced a significant increase in fat oxidation in C2C12 muscle cells and adipocyte tissue and decreased fatty acid synthase (FAS) expression in the adipocytes [12]. A few previous studies showed that supplementation with leucine increases hepatic and muscle glycogen concentrations [13], suggesting greater fat used during exercise. Anacardic acids supplementation was also shown to decrease body fat deposition. Uncoupling action of anacardic acids on the mitochondrial oxidative phosphorylation was proposed [14].

## Cashew Apple Juice and Oxidative Stress

Our previous work showed that supplementation with CAJ for 4 weeks increased antioxidant such as superoxide

dismutase and reduced inflammation in cyclists. These are important factors contributing to increase exercise tolerance [15]. Vitamin C is a potent water-soluble antioxidant in humans. It is called an antioxidant due to preventing other compounds from being oxidized [16]. The vitamin C plays important roles in cellular function and has been implicated in processes associated with aging, including vascular, inflammatory damage and cancer. High-intensity exercise increases the generation of free radicals and lipid peroxidation. Thus, it induces oxidative damage and result in muscle injury. The vitamin C is shown to cope with the enhanced production of free radicals and thus decrease in the rate of lipid peroxidation [17]. Anacardic acids are also a strong antioxidant [2]. In the hypoxanthine/xanthine oxidase assay, they predominantly function in a suppression of superoxide generation and inhibition of xanthine oxidase and thus ameliorate reactive oxygen species (ROS) attack and protect DNA damage induced by ROS [18].

### Cashew Apple Juice and Immune Function

Our recent study found that supplementation with CAJ for 4 weeks increased total leukocyte and neutrophil counts which were mediated by reduced oxidative product such as malondialdehyde and 8-isoprostane (not published yet). In rats, da Silveira Vasconcelos and colleagues found that CAJ improved the immunological mechanisms and optimized balance between ROS and antioxidants leading to better wound healing [1]. In aspect of ergogenic aids, vitamin C supplementation  $\geq 1000\text{mg/day}$  augmented the increase in lymphocyte counts after exercise in ultra marathon runners [19]. Vitamin C is an immune system booster par excellence. It can maintain an effective immune response [20]. There are some evidences reported that vitamin C strengthens and protects the immune system by stimulating the activity of antibodies and immune system cells such as phagocytes and neutrophils. In addition, it may in theory neutralize the ROS that are produced especially during high-intensity exercise by maintaining the redox integrity of immune cells and thereby protects them against ROS [21]. Anacardic acids have also reported to increase heme oxygenase-1 which is an antioxidant enzyme involving immune system [22].

### Cashew Apple Juice and Cardiac Autonomic Function

In my previous work we proved that a single dose of CAJ supplementation at  $3.5\text{ml/kg}$  body mass augmented parasympathetic (vagal) activity during high-intensity exercise in athletes [23]. An animal study also observed that vitamin C supplementation stimulated the vagal activity [24]. The vitamin C may act through a mechanistic pathway mediated by increased vagal and decreased sympathetic activities [25]. In patients with chronic heart failure (CHF), vitamin C supplementation improved vagal sinus modulation. These data open the possibility that the vitamin C acts directly on the sinoatrial node or sub endothelial nerve endings at the

baroreceptor level such as carotid, aortic, or cardiopulmonary and acts indirectly by improving hemodynamic [26].

### Conclusion

The cashew apple juice (CAJ) is a product of cashew apple manufactures. It is rich in complex nutrients including vitamin C, branched-chain amino acids, and anacardic acids. These components yield their beneficial effects on health. In aspect of ergogenic aids, acute and chronic CAJ supplementation enhances body metabolism, antioxidant activity, immune cell activity, and cardiac autonomic activity during high-intensity exercise. Thus, the CAJ is a healthy drink which has potential effects on both sport and health promotion.

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