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Study on the role of nutrients in food to improve the motion state of athletes

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PAPER

Abstract

This study aims to analyze the role of nutrients in food in improving athletic performance and to understand the feasibility of food supplementation in sports training. Twenty athletes were randomly divided into two groups, A and B. The athletes in the two groups had the same diet and the same training content and differed only in the supplemented food. Group A was supplemented with *Siraitia grosvenorii* water, and Group B was supplemented with pure water. After 3 months of training, the body composition, exercise status, and blood indexes of the athletes in the two groups were compared. Compared with the athletes in group A before the experiment as well as in group B after the experiment, the athletes in group A showed a significant increase in fat-free weight, improved athletic performance, increased levels of hemoglobin (Hb) and red blood cell (RBC), and decreased levels of blood lactic acid (BLA) and blood urea nitrogen (BUN) ($P < 0.05$). Nutrients in food can effectively improve the body composition and exercise status of athletes and inhibit the decrease of Hb and RBC as well as the increase of BLA and BUN, which have good usability in sports training.

Keywords: athletes; food; motion state; nutrient

Introduction

In the process of improving sports performance, athletes need to carry out a lot of training and fierce competition; in such a case, the body state of athletes declines (Chuckravanen *et al*., 2019), free radicals accumulate, fatigue appears, and immune function declines, which may cause sports injury and directly affect the training effect and the results of competition. Therefore, the question of how to reduce the impact of a rigorous training on athletes and improve motion state has been widely concerned by researchers. In nature, many foods are rich in nutrients, which can be used as nutritional supplements for athletes. Guo (2015) studied jujube polysaccharides and carried out the weight-bearing swimming experiment on rats. They found that rats had significantly longer swimming time, larger body weight, and higher glycogen content after taking jujube polysaccharides. Liu *et al*. (2015) studied the polysaccharide components of *Hericium erinaceus*, analyzed its anti-fatigue activity, compared various indexes of mice under different doses of *Hericium erinaceus* polysaccharide, and found that it could reduce the content of blood lactic acid (BLA) and malondialdehyde (MDA). Zhang *et al*. (2015) simulated the plateau environment and analyzed the anti-fatigue effect of *Astragalus membranaceus* on mice. It was found that the swimming time of mice was prolonged, the lactic acid decreased, and the glycogen increased under the influence of *Astragalus membranaceus*, which indicated that *Astragalus membranaceus* could reduce the fatigue of mice in a plateau environment. Ren *et al*. (2017) studied the effect of soy whey protein supplementation on sports performance after long-term training. It was found that the average fatigue time of rats was longer,

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the activity of lactate dehydrogenase was higher, and the level of MDA was lower after supplementation of soybean whey protein. In this study, the nutrients in *Siraitia grosvenorii* were studied, and a comparative experiment was carried out. The indicators of the athletes, such as body composition and motion status, were analyzed to understand the application prospect of *Siraitia grosvenorii* in sports training.

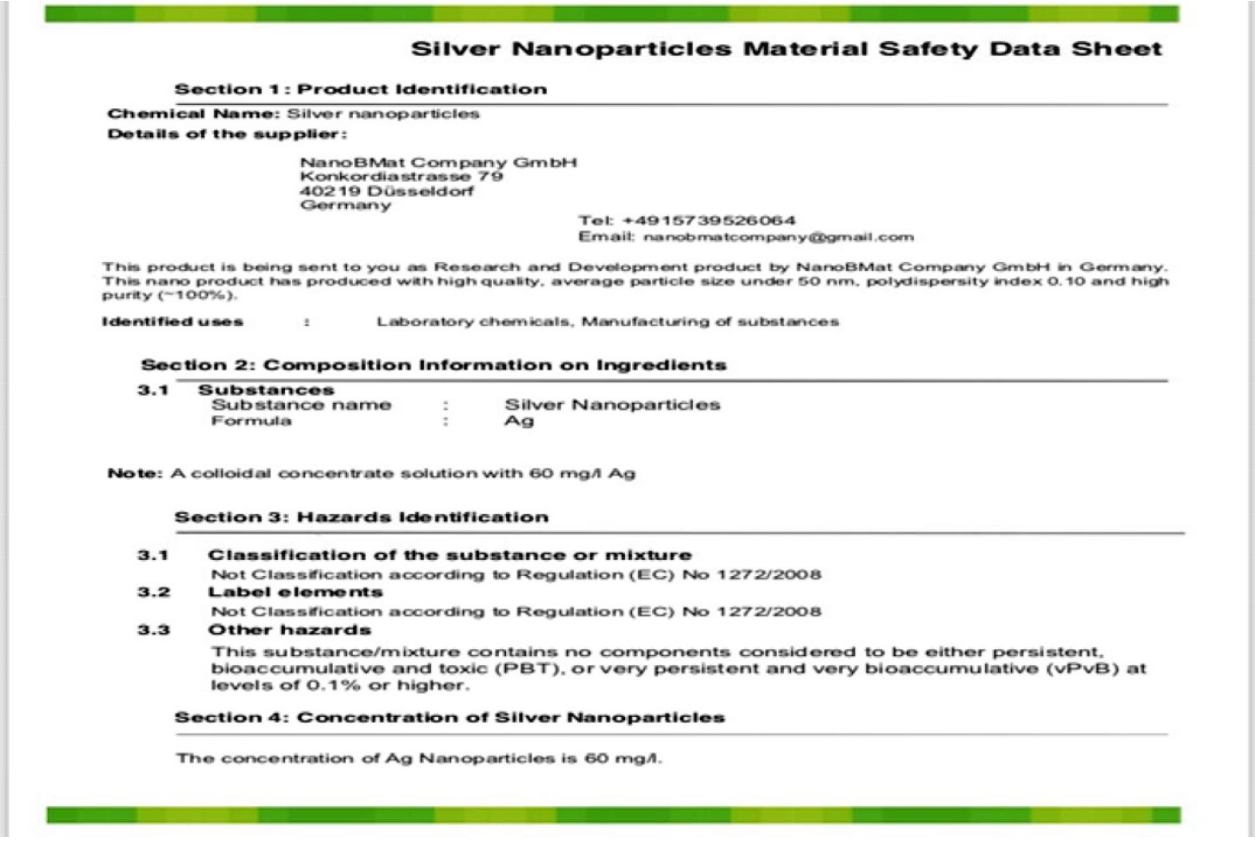
Nutrients in *Siraitia grosvenorii* and Their Functions

Siraitia grosvenorii is a kind of medicinal and edible material unique to China (Tu *et al*., 2015). It is mainly produced in provinces such as Guangxi and Guangdong in southern China. The fruits of *Siraitia grosvenorii* are spherical or oblong (Figure 1, left). The mature fruits have dark green pericarp, yellowing petioles, and high water content. After being processed and dried (Figure 1, middle), the surface is brown or yellowish-green with dark patches; it is light, brittle, and easy to crack, and the seeds are oblate (Figure 1, right), light red to reddish-brown, with a sweet taste.

Siraitia grosvenorii contains many cucurbitane triterpenoids (Niu *et al*., 2017; Qiao *et al*., 2019), which are sweet or slightly sweet substances (Shi *et al*., 2019). The sweet or slightly sweet substances have high sweetness and low heat, which can substitute for sucrose (Abdel-Hamid *et al*., 2020). It also contains flavonoids, but the content is not high. Moreover, there is a lot of protein and amino acids in *Siraitia grosvenorii*, including eight kinds of essential amino acids for the human body. The sugar content in *Siraitia grosvenorii* is very high, and the content of fructose is 14%. It contains 24 kinds of inorganic elements. The content of oil or fat is also very high, and the main component is squalene. It also contains rich vitamin C and vitamin E, suggesting high nutritional values.

The most important medicinal value of *Siraitia grosvenorii* is clearing away heat and moistening the lung (Gong *et al*., 2019). According to traditional Chinese medicine, *Siraitia grosvenorii* is sweet and cool; therefore, it has a good therapeutic effect on lung heat and dry cough. The medicinal value of *Siraitia grosvenorii* also includes:

(1) Resistance to diabetes (Xu *et al*., 2020). *Siraitia grosvenorii* has high sweetness and low calorie. It can be used as an ideal sugar substitute for diabetes mellitus patients. Also, some components in *Siraitia grosvenorii* can reduce blood glucose and blood lipid and improve renal function.



Silver Nanoparticles Material Safety Data Sheet

Section 1 : Product Identification

Chemical Name: Silver nanoparticles
Details of the supplier:

NanoBMat Company GmbH
Konkordiastrasse 79
40219 Düsseldorf
Germany

Tel: +4915739526064
Email: nanobmatcompany@gmail.com

This product is being sent to you as Research and Development product by NanoBMat Company GmbH in Germany. This nano product has produced with high quality, average particle size under 50 nm, polydispersity index 0.10 and high purity (~100%).

Identified uses : Laboratory chemicals, Manufacturing of substances

Section 2: Composition Information on Ingredients

3.1 Substances
Substance name : Silver Nanoparticles
Formula : Ag

Note: A colloidal concentrate solution with 60 mg/l Ag

Section 3: Hazards Identification

3.1 Classification of the substance or mixture
Not Classification according to Regulation (EC) No 1272/2008

3.2 Label elements
Not Classification according to Regulation (EC) No 1272/2008

3.3 Other hazards
This substance/mixture contains no components considered to be either persistent, bioaccumulative and toxic (PBT), or very persistent and very bioaccumulative (vPvB) at levels of 0.1% or higher.

Section 4: Concentration of Silver Nanoparticles

The concentration of Ag Nanoparticles is 60 mg/l.

Figure 1. ***Siraitia grosvenorii.***

(2) Protect the cardiovascular system. *Siraitia grosvenorii* is rich in unsaturated fatty acids, which can resist fatty liver; inorganic salts, such as selenium and magnesium, can protect myocardial cells and are also effective in expanding blood vessels and preventing thrombosis.
(3) Improve immunity. *Siraitia grosvenorii* has antibacterial and anti-inflammatory effects (Li *et al*., 2018), which can enhance the cellular and humoral immune functions of the body and coordinate the immune system.

Experimental Methods

Research subjects

Twenty athletes were randomly selected from the Ministry of Public Sports of Zhejiang Shuren University. They were informed of the intention and process of the experiment. All the participants were randomly divided into group A and group B. Group A drank water soaked with *Siraitia grosvenorii*, while group B drank pure water. The athletes in both groups were in good health and had no physical injury within half a year. They took no strenuous exercise and did not take any caffeine or tea 24 h before the experiment. They were in a good mental state. There was no significant difference in general data, as shown in Table 1.

Research methods

The two groups of athletes were trained for 3 months, including sprinting, long-distance running, standing long jump, etc. They were trained twice a day, 2 h each session. The athletes took three meals in the school canteen every day, without any additional nutrition. The athletes in group A drank the water soaked with *Siraitia grosvenorii* at 8:00, 12:00, 16:00, and 20:00 every day, while the athletes of group B drank pure water. The dosage of *Siraitia grosvenorii* soaking water was 1/4 *Siraitia grosvenorii* and 1 L water, for four times, 250 ml each time. Before and after the experiment, blood samples and motion state tests were carried out on the athletes. The indexes are shown in Table 2.

Measurement index

Body composition: body weight and fat-free weight.

Movement state: as shown in Table 2.

Table 1. Comparison of general information.

	Group A (n = 10)	Group B (n = 10)
Age/years	22.78 ± 2.31	23.08 ± 1.56
Height/cm	178.64 ± 2.78	177.59 ± 3.08
Weight/kg	76.21 ± 5.29	75.94 ± 6.12

Table 2. Measurement indexes of motion state.

Number	Content
X1	Standing long jump
X2	One minute push-ups
X3	One minute sit-ups
X4	50-m running
X5	Sit and reach

Measurement index

Blood indicators: including hemoglobin (Hb), red blood cell (RBC) count, BLA, and blood urea nitrogen (BUN).

Blood samples were sent to Hangzhou Second People's Hospital for testing.

Statistical analysis

The data were statistically processed by SPSS17.0 and expressed as $\bar{x} \pm SD$. The comparison between groups was conducted using the t-test. If the value of P was smaller than 0.05, then it suggested that there was a statistical difference.

Experimental Results

Comparison of body composition

Before and after the experiment, the changes in body composition of athletes in the two groups are shown in Table 3.

As shown in Table 3, before the experiment, there was no significant difference in body weight and fat-free weight between group A and group B ($P > 0.05$); after the experiment, the fat-free weight and body weight of athletes in the two groups increased slightly, and the fat-free weight of group A was 59.33 ± 3.25 kg, significantly higher than that before the experiment ($P < 0.05$) and group B, indicating that drinking *Siraitia grosvenorii* water was effective in improving athletes' fat-free weight.

Comparison of motion state

Before and after the experiment, the comparison of the motion state between the two groups of athletes is shown in Table 4.

As shown in Table 4, before the experiment, there was no significant difference in different motion states between the two groups; after the experiment, the standing long jump of group A was 2.62 ± 0.71 m, which showed a significant improvement compared with that before the experiment and group B; the number of push-ups in group A was 38.71 ± 3.59, and $P < 0.05$ compared to

Table 3. Changes in body composition.

	Group A		Group B	
	Before the experiment	After the experiment	Before the experiment	After the experiment
Weight/kg	76.21 ± 5.29	77.33 ± 4.62	75.94 ± 6.12	76.89 ± 5.78
Fat-free weight/kg	53.64 ± 0.86	59.33 ± 3.25*#	54.68 ± 1.12	56.48 ± 2.86

*Compared with that before the experiment, P < 0.05.
#Compared with group B, P < 0.05.

Table 4. Comparison of motion state.

	Group A		Group B	
	Before the experiment	After the experiment	Before the experiment	After the experiment
X1/m	2.43 ± 0.83	2.62 ± 0.71*#	2.51 ± 0.76	2.53 ± 0.48
X2/n	33.68 ± 4.86	38.71 ± 3.59*#	34.12 ± 4.77	35.62 ± 4.63
X3/n	37.12 ± 3.08	41.29 ± 5.57*#	37.25 ± 3.12	39.68 ± 4.51
X4/s	6.32 ± 0.33	5.88 ± 0.41*#	6.41 ± 0.27	6.03 ± 0.39*
X5/cm	15.33 ± 0.71	16.21 ± 0.33	16.12 ± 0.78	16.23 ± 0.56

*Compared with that before the experiment, P < 0.05.
#Compared with group B, P < 0.05.

Table 5. Comparison of Hb and RBC.

	Group A		Group B	
	Before the experiment	After the experiment	Before the experiment	After the experiment
Hb (g/L)	136.77 ± 1.87	141.34 ± 0.64*#	137.64 ± 0.92	131.66 ± 1.91*
RBC (1012/L)	4.63 ± 0.12	5.09 ± 0.26*#	4.57 ± 0.19	4.77 ± 0.21

*Compared with that before the experiment, P < 0.05.
#Compared with group B, P < 0.05.

before the experiment and group B; the number of sit-ups in group A was 41.29 ± 5.57, which was significantly different from that before the experiment and group B; the performance of the 50 m running of group A was 5.88 ± 0.41 s (P < 0.05 compared to before the experiment and group B), and the performance of group B also significantly improved after the experiment; finally, there was no significant difference in sit and reach before and after the experiment and between the two groups (P > 0.05). It was found that drinking *Siraitia grosvenorii* water was effective in improving athletes' performance and motion state.

Comparison of blood indexes

Before and after the experiment, the comparison of Hb and RBC count between the two groups is shown in Table 5.

It was seen from Table 5 that there was no significant difference in the comparison of Hb and RBC between the two groups before the experiment; after the experiment, the Hb of group A increased, while that of group B decreased, suggesting significant differences compared with that before the experiment, and the Hb value of group A was significantly higher than that of group B (P < 0.05); after the experiment, the RBC value of group A significantly increased, and P < 0.05 compared to that before experiment and group B. It was found that drinking *Siraitia grosvenorii* water could increase the RBC count and inhibit the decrease of Hb value.

The comparison of BLA and BUN between the two groups is shown in Figure 2.

As shown in Figure 2, before the experiment, the BLA values of the two groups were 3.27 ± 0.21 mmol/L and 3.26 ± 0.33 mmol/L, respectively, suggesting no significant difference; after the experiment, the BLA of group A increased to 8.16 ± 0.78 mmol/L, while that of group B increased to 11.27 ± 0.56 mmol/L, which were significantly different from those before the experiment, and the BLA value of group A was significantly smaller

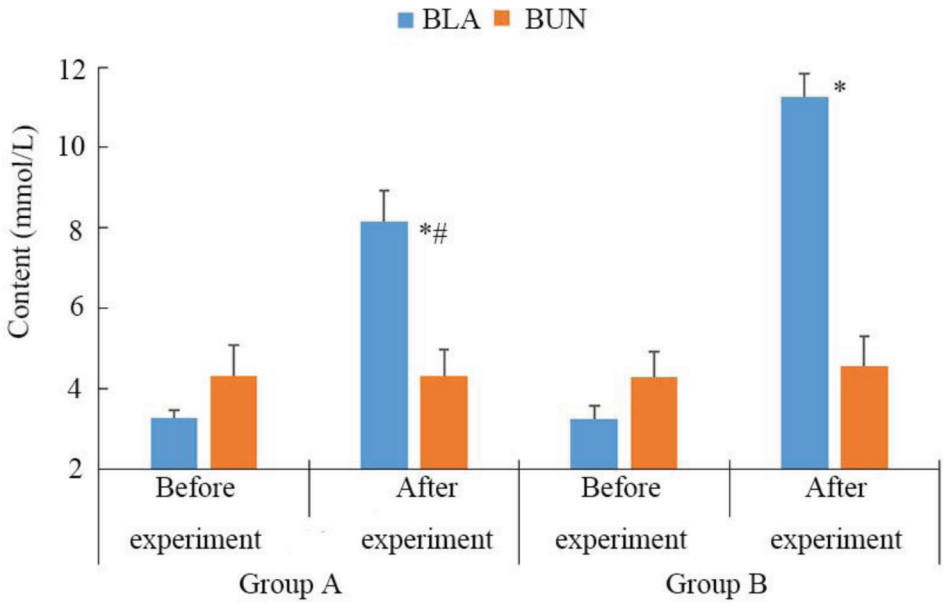


Figure 2. Comparison of BLA and BUN.
*P < 0.05 compared to before experiment. #P < 0.05 compared to group B.

than that of group B (P < 0.05); before the experiment, the BUN value of two groups were 4.31 ± 0.78 mmol/L and 4.29 ± 0.64 mmol/L, respectively; after the experiment, the BLA values of the two groups were 4.33 ± 0.64 mmol/L and 4.56 ± 0.74 mmol/L, respectively, which showed a slight increase, but the difference was not obvious. It was found that drinking *Siraitia grosvenorii* water could inhibit the growth of BLA.

Discussion

In exercise, the nutrients in the body are consumed rapidly, and the demand for protein and sugar increases. To improve the sport's ability of the human body, the supplement of nutrients is very important. By supplementing some foods with rich nutrients, the metabolic needs of athletes can be ensured to have good health state. Many foods contain a lot of nutrients, which can be widely used to improve the state of human movement. In this study, the nutrients in *Siraitia grosvenorii* were studied.

Based on the data shown in Tables 3 and 4, it was found that after the experiment, the fat-free weight of athletes who drank *Siraitia grosvenorii* water increased, and their standing long jump and push-up performance also improved. It shows that the motion state of athletes in group A significantly improved, and their sports performance was better after the experiment.

Hb is the carrier of O_2 and CO_2. In the process of long exercise sessions, a lot of free radicals appear in the human body and destroy RBC. Therefore, after a lot of exercise, the content of Hb in the human body decreases. As shown in Table 5, the Hb of athletes in group B decreased from 137.64 ± 0.92 g/L to 131.66 ± 1.91 g/L, while group A drank *Siraitia grosvenorii* water and had increased Hb value rather than decreased Hb value. The results showed that the nutrients in *Siraitia grosvenorii* could protect RBC, maintain the function of RBC, inhibit the decline of Hb, and improve the human body's movement state.

When the body exercises, lactic acid generated by the skeletal muscles enters the blood and is later eliminated by the process of metabolism. In the case of a large amount of exercise, the BLA in the human body increases rapidly, resulting in the accumulation of lactic acid (Romadhona *et al*., 2019), and the metabolic level decreases, which leads to the decline of exercise ability. The results showed that the BLA value of group A and group B increased significantly after the experiment, but the BLA value of group A was smaller than that of group B (P < 0.05), which showed that nutrients in *Siraitia grosvenorii*, such as flavonoids, protected the cardiovascular system, and enhanced the metabolic capacity of the body, thus reducing the accumulation of lactic acid, maintaining the balance of the internal environment, relieving fatigue, and improving the exercise state of the human body.

BUN can reflect the body's protein metabolism. With the progress of exercise, the protein metabolism in the body increases, and the urea content becomes higher, which is not conducive to maintaining physical fitness. The results

showed that the BUN values of the two groups increased slightly after the experiment, and the value of group A was slightly smaller than that of group B, but the difference was not obvious. It indicated that *Siraitia grosvenorii* water could stabilize the protein level, and inhibit the increase of BUN, thus improving the movement state of the human body.

Conclusion

This paper mainly studied nutrients in food with *Siraitia grosvenorii* as an example and its role in improving the athletic performance of athletes. Through the experiment and the analysis of the results, it was found that drinking *Siraitia grosvenorii* water could improve the athletes' fat-free weight, enhance the exercise state, inhibit the decrease of Hb, maintain the stability of RBC, reduce the production of BLA, restrain the increase of BUN, which had a positive role in improving the motion state of athletes. *Siraitia grosvenorii* water can be promoted and applied in practice.

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