

Effects of various extract drinks on endurance in long-distance running training

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Received: 20 February 2024; Accepted: 4 June 2024; Published: 1 July 2024

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ORIGINAL ARTICLE

Abstract

This paper briefly introduces plant extracts and their combinations with sports drinks. The research involved 40 sportsmen who are affiliated with the Track and Field Department of the School of Physical Education in South-Central Minzu University. This paper aimed to explore the influence of sports drinks enhanced with extracts of *Codonopsis pilosula* and *Acanthopanax senticosus* on the endurance levels of long-distance runners. The participants were divided into four groups: a placebo group, a group receiving only *C. pilosula*, a group receiving *A. senticosus*, and a composite group. Endurance performance indices for long-distance running were evaluated both before and after the training. Before training, the heart rate, blood lactate level, and maximum oxygen uptake of the placebo group were 159.53 ± 2.21 times/min, 9.7 ± 1.2 mmol/L, and 66.18 ± 2.35 mL/kg/min, respectively; the single *Codonopsis pilosula* group was 158.33 ± 2.24 times/min, 9.6 ± 1.1 mmol/L, and 65.87 ± 1.88 mL/kg/min, respectively; the single *Acanthopanax senticosus* group was 159.66 ± 3.67 times/min, 9.7 ± 1.0 mmol/L, and 66.32 ± 1.47 mL/kg/min, respectively; the *Codonopsis pilosulae* and *Acanthopanax senticosus* composite group was 158.21 ± 1.28 times/min, 9.6 ± 0.9 mmol/L, and 66.87 ± 1.12 mL/kg/min, respectively. After training, the corresponding values of the placebo group were 162.53 ± 3.21 times/min, 9.6 ± 0.8 mmol/L, and 68.85 ± 3.25 mL/kg/min, respectively; the single *Codonopsis pilosula* group was 145.33 ± 2.25 times/min, 9.1 ± 0.5 mmol/L, and 73.69 ± 2.58 mL/kg/min, respectively; the single *Acanthopanax senticosus* group was 142.66 ± 3.69 times/min, 9.1 ± 0.8 mmol/L, and 73.84 ± 2.19 mL/kg/min, respectively; the composite group was 131.21 ± 1.36 times/min, 8.3 ± 0.3 mmol/L, and 77.19 ± 3.14 mL/kg/min, respectively. Sports drinks that include extracts of *C. pilosula* and *A. senticosus* significantly increased endurance levels. The concurrent use of *C. pilosula* and *A. senticosus* was more beneficial in enhancing endurance performance for long-distance running in comparison to using each extract individually.

Keywords: endurance, long-distance running, plant extract, sports drink

Introduction

In contemporary society, there is an increasing emphasis on the maintenance of good health and endurance (Berry *et al.*, 2022). Long-distance running is recognized for its role in improving cardiopulmonary function, increasing endurance, and promoting overall well-being. However, the depletion of energy and fluids in the human body

during long-distance running raises questions about the effective replenishment of energy and hydration (Emond *et al.*, 2015), as well as the enhancement of endurance for individuals who regularly engage in this activity. Traditional sports drinks are frequently used to address these requirements. Nevertheless, these beverages often contain additives and inorganic chemicals that may present health risks. Therefore, the use of natural and

healthy ingredients is necessary to address these needs (Macdonald, 2019). Plant extracts, known for their natural antioxidant properties and nutritional benefits, have been shown to possess various biological effects such as boosting the immune system, enhancing cardiovascular health, and alleviating fatigue. As a result, the incorporation of plant extracts into sports beverages is considered a safer and more efficient strategy to combat exhaustion and enhance endurance in long-distance runners (Ahmad *et al.*, 2022). Zhang *et al.* (2020) explored the effects of NaCl on the pH, total soluble solids, phenolic compounds, anthocyanins, and 2,2-diphenyl-1-picrylhydrazyl free radical scavenging activity in grape juice at different temperatures. They found that NaCl had the potential to preserve the quality and extend the shelf life of grape juice without the need for additional preservatives. Moreover, NaCl-treated grape juice was found to be beneficial in replenishing lost fluids, electrolytes, and antioxidants during exercise. Gramza Michalowska *et al.* (2017) designed a formula for gluten-free oat beverages enriched with bioactive plant ingredients and assessed their antioxidant capacity. They found that adding tea, stevia extract, and mulberry preparations to oat beverages enhanced their antioxidant potential. Begum *et al.* (2015) investigated the impact of various formulations of sports drinks, as well as water and no beverage intake, on fluid balance and exercise performance during high-intensity interval exercise. The results showed that homemade beverages exhibited comparable effects in enhancing exercise performance to commercial drinks. However, both types of beverages were inferior to water in terms of hydration efficacy. Hasegawa *et al.* (2019) examined the potential of carbonated sports drinks to promote fatigue recovery after high-intensity exercises. They found that consumption of these drinks after intense exercise indeed facilitated fatigue recovery, with the observed effect being influenced by gender. Fernández-Campos *et al.* (2015) studied the acute effects of energy drinks on physical performance in professional female volleyball players and found that acute consumption of energy drinks did not yield any enhancements in the athletes' physical performance. Roldán *et al.* (2017) examined the impact of caffeine-containing energy drinks on alcohol consumption levels and found that these drinks promoted alcohol consumption in the body. The above-mentioned studies have all focused on sports drinks with energy-supplementing properties, with some testing the physicochemical properties of these drinks and others examining their effects on athletes. This study, however, investigated the impact of sports drinks containing plant extracts such as *Codonopsis pilosula* and *Acanthopanax senticosus* on long-distance running endurance in athletes, providing a valuable reference for developing sports beverages aimed at enhancing athletic performance. This paper conducted tests involving 40 athletes from the Track and Field Department of the School of Physical

Education at South-Central Minzu University, with the aim to evaluate the effects of sports drinks enriched with extracts derived from *C. pilosula* and *A. senticosus* on endurance performance during long-distance running.

Plant Extracts

In sports drinks, there are usually multiple ingredients including sugar, electrolytes, vitamins, etc., which can provide energy for athletes, maintain hydration balance, and promote muscle recovery. However, traditional sports drinks often achieve the above effects through additives and chemical components, which can have negative impacts on health (Li *et al.*, 2019). Plant extracts as a natural nutritional component can replace the traditional additives and chemical components in sports drinks and are relatively safer and more effective. Plant extracts refer to substances that are processed by extracting appropriate solvents or methods from plants as raw materials and can be applied in industries such as medicine, food, and cosmetics. During the extraction process of plants, physical-chemical means are used to selectively obtain and concentrate the active ingredients in plants according to the desired final product without altering their structural integrity. There is a conceptual overlap between plant extracts and herbal extracts because many herbs themselves are plants with valuable medicinal components being the desired active ingredients. Some herbal active ingredients have low natural content; therefore, they undergo extraction and concentration processes to enhance their medicinal effects. The extracted herbal active ingredients not only serve directly as medicines but also can be added into diluted beverages to give them health benefits.

A wide range of plant extracts can be added to sports drinks, such as *Codonopsis pilosula*, *Lycium chinensis*, and *Acanthopanax senticosus*. These natural extracts are abundant in polysaccharides, flavonoids, amino acids, and other components. They possess various biological activities, including antioxidant properties, anti-inflammatory effects, and fatigue reduction (Gao and Zhang, 2015). *Codonopsis pilosula*, a commonly used Chinese herbal medicine, is renowned for its benefits in enhancing digestive function, boosting energy levels, and alleviating thirst. In the context of long-distance running, the active ingredients of *C. pilosula* contribute to energy and water metabolism, enhance cardiorespiratory function and endurance, promote blood circulation, improve microcirculation, and diminish the risk of sports injuries. *Acanthopanax senticosus* is an herbal remedy known for its beneficial effects on the liver and kidney, as well as its ability to fortify musculoskeletal tissues. It contains active ingredients that can stimulate osteogenesis and myogenesis, enhance resistance against fatigue, optimize

blood circulation, and support cardiopulmonary function and endurance during prolonged running (Bargoria *et al.*, 2020).

The active constituents in the aforementioned botanicals have the potential to enhance cardiopulmonary function and blood circulation, thereby boosting endurance during long-distance running. These ingredients can effectively replace conventional additives and chemical components in sports drinks, minimizing potential side effects while retaining the supplementary benefits of sports drinks for long-distance running training. Additionally, incorporating the active ingredients of medicinal herbs into sports drinks serves a dual purpose. First, it dilutes these active components, thereby mitigating the side effects associated with high doses of medicinal ingredients and enabling a more nuanced impact. Second, sports drinks can improve the taste and flavor of these active components, thereby increasing overall acceptance by athletes (Hermand *et al.*, 2020).

Case Analysis

Materials and equipment

Materials

Codonopsis pilosula and *Acanthopanax senticosus* were purchased from a pharmacy in Wuhan; sucrose (food grade) was obtained from a local supermarket in Wuhan; citric acid (food grade) from Henan Tuoyuan Chemical Products Co., Ltd., China; and anhydrous ethanol (Morris and Jay, 2016) (analytically pure) from Dongneng Chemical, China.

Equipment

Electronic balance was purchased from XPR226DRQ/AC, Mettler Toledo, Switzerland; pH meter (PHSJ-5T) from Shanghai Yidian Scientific Instrument Co., Ltd., China; pulverizer (CJ-60) from Shandong Jingxin Powder Equipment Technology Co., Ltd., China; high-pressure homogenizer (KS-2000M) from Kaibaisi Nanotechnology Co., Ltd., China; dry-heat sterilizer (DMH-6ZG) from Nanjing Wohuan Science & Technology Co. Ltd., China; high-speed centrifuge (TGL16-WS) from Changzhou

Runhua Electric Appliances Co., Ltd., China; blood lactate analyzer (BIOSEN C_Line) from Beijing D.F.K. Technology and Trade Co., Ltd., China; and gas metabolism analyzer (MasterScreen CPX) from Huanxi Medical, China).

Preparation process of sports drinks

The preparation process of the sports drink with the addition of *C. pilosula* and *A. senticosus* is shown in Figure 1. The steps were as follows:

- (1) The herbs were washed and dried.
- (2) The herbs were pulverized using a pulverizer and passed through an 80-mesh sieve.
- (3) 50 g of the powder was taken using an electronic balance, added with 1000 mL of water, and extracted using 300 W ultrasonic for 60 min under 60°C water bath heating. It was condensed by continuous heating.
- (4) The concentrated solution was supplemented with anhydrous ethanol at a volume five times that of the concentrated solution, followed by thorough mixing and overnight standing. Then, precipitation was separated through filtration using a high-speed centrifuge. The herb extract was obtained by evaporating the ethanol from the precipitate.
- (5) The herb extract was taken and added with water.
- (6) To prepare the sports drink, the aqueous solution of the extract, sucrose, and citric acid was mixed in certain proportions (the exact proportions will be described later in the comparative test program).
- (7) After two rounds of stirring using a high-pressure homogenizer (Storelli, 2015), the solution is filled into containers.
- (8) The filled beverage was sterilized in a dry heat sterilizer at 120°C for 10 min. The plant-extract sports

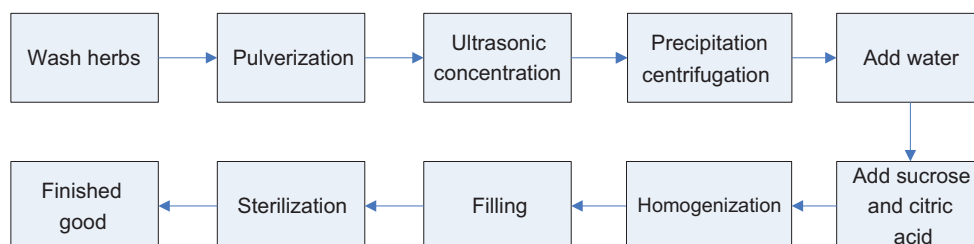


Figure 1. Flow of sports drink preparation.

drink was obtained when the drink was cooled (Kalkan *et al.*, 2018).

Testing the impact of extracted beverages on long-distance running endurance

Study subjects

Forty athletes from the Track and Field Department of the School of Physical Education at South-Central Minzu University were tested to examine the effect of the *C. pilosula* and *A. senticosus* extract drink on endurance in long-distance running. The 40 athletes had been training for long-distance running for 1 year, with an average age of 20 ± 0.2 years, an average height of 175 ± 1.2 cm, and an average body weight of 70 ± 0.3 kg. They had no family history of medical problems, were not injured within the past 3 months, and signed an informed consent form prior to participation. The athletes were randomly assigned into four groups: a placebo group, a single *Codonopsis pilosula* group, a single *Acanthopanax senticosus* group, and a composite group.

In the placebo group, the sports drink contained only 6% sucrose and 0.5% citric acid. The sports drink for the single *Codonopsis pilosula* group included 15% *C. pilosula* extract in addition to 6% sucrose and 0.5% citric acid. Similarly, the sports drink for the single *Acanthopanax senticosus* group contained 15% *A. senticosus* extract in addition to 6% sucrose and 0.5% citric acid. The sports drink for the composite group contained 15% *A. senticosus* extract and 15% *A. senticosus* extract in addition to 6% sucrose and 0.5% citric acid.

Testing method

The effect of plant extracts on endurance training for long-distance running was tested for 6 weeks. The four groups of athletes underwent pre- and post-training endurance tests while consuming their respective sports drinks during the long-distance running sessions. The daily long-distance running training program included: (1) rest for 1 h after uniform breakfast in the morning, followed by a 15-minute warm-up session; (2) run 2000 m three times, drink 600 mL of the sports drink after each time of running, and rest 35 min after each time of running, during which the coach helped them to relax; (3) rest until the lunchtime after the long-distance running; (4) 2 h of free time after the lunch; (5) do 15-minute warm-up activities, complete two sets of running for a distance of 2000 m each time, drink 600 mL of the sports drink following each running session, rest 35 min after each run, during which the coach helped them to relax; (6) the period from the conclusion of dinner to 22:00 was the free time, and the period after 22:00 was the time for sleep.

The endurance testing program before and after long-distance running training included the following content.

- (1) *Heart rate*: The weight of the athletes was measured using a scale. Each wore a heart rate belt to monitor real-time heart rate, followed by a 5 km run.
- (2) *Blood lactate*: Fingertip blood was collected using capillary glass tubes 10 min before and at the end of the long run, and blood lactate tests were performed using a blood lactate analyzer to determine the relative change in blood lactate levels.
- (3) *Maximal oxygen uptake*: No strenuous exercise was allowed 12 h prior to the maximal oxygen uptake test, and fasting was allowed 2 h before the test. Both the gas metabolism analyzer and the running platform were calibrated and warmed up before the official start of the test. At the start of the test, the athlete warmed up for 10 min, wore a heart rate belt and a mask and ensured no air leakage from the mask. The athlete ran on a running platform at a slope of 10° and a speed of 100 m/min, and then the values were increased by 2° and 20 m/min every 3 min until exhaustion. Exhaustion criteria included an increase in slope and speed without any change or decrease in maximal oxygen uptake, a heart rate exceeding 180 beats per minute, or voluntary termination by the subject.

Statistical analysis

The collected data were entered into Excel, and the data were analyzed using SPSS software (Scherer *et al.*, 2018). The calculation results were expressed in the form of $\bar{x} \pm s$. A T-test was used. The difference was determined as statistically significant when the P value was less than 0.05.

Test results

The changes in heart rate of the four groups of athletes before and after training are shown in Table 1. Specific data will not be repeated here. From Table 1, it can be seen that before training, the differences in the mean heart rate among the four groups of athletes were not significant to each other, and the P values between the groups exceeded 0.05. After training, the differences in the mean heart rate among the four groups arose, and the P values were less than 0.05 except for the P value between groups B and C, i.e., the groups that drank the sports drinks containing extracts of *C. pilosula* and *A. senticosus* had lower mean heart rates for long-distance running than the group using the conventional sports drink, while there was no significant difference between the groups drinking single-extract sports drinks. The group drinking a drink made from *C. pilosula* and *A. senticosus* extracts

Table 1. Changes in heart rate before and after training in four groups of athletes.

Time period	Group	Heart rate (beats/min)	P _{AB}	P _{AC}	P _{AD}	P _{BC}	P _{BD}	P _{CD}
Pre-training	A – The placebo group	159.53 ± 2.21	0.125	0.235	0.311	0.129	0.119	0.214
	B – The single <i>Codonopsis pilosula</i> group	158.33 ± 2.24						
	C – The <i>Acanthopanax senticosus</i> group	159.66 ± 3.67						
	D – The composite group	158.21 ± 1.28						
Post-training	A – The placebo group	162.53 ± 3.21	0.011	0.009	0.001	0.125	0.012	0.011
	B – The single <i>Codonopsis pilosula</i> group	145.33 ± 2.25*						
	C – The <i>Acanthopanax senticosus</i> group	142.66 ± 3.69*						
	D – The composite group	131.21 ± 1.36**						

* and ** denote $P < 0.05$ and $P < 0.01$ in the comparison within the same group before and after training.

P_{ij} denotes the difference between groups i and j in the same period.

had a lower mean heart rate for long-distance running than groups drinking single-extract sports drinks.

Upon comparing the mean heart rates of the same group before and after training, it was found that there were no significant changes in the mean heart rates before and after training in the placebo group. Conversely, both the single *Codonopsis pilosula* and single *Acanthopanax senticosus* groups exhibited significantly lower mean heart rates after training. Notably, the composite group demonstrated an even more substantial reduction in the mean heart rate after training.

The relative changes in blood lactate during long-distance running between the four groups of athletes before and after training are shown in Table 2, and the specific data will not be repeated. As can be seen from Table 2, there was no significant difference in the relative change in blood lactate during long-distance running among the four groups of athletes before training. After training, the differences in the relative changes in blood lactate during long-distance running among the four groups of athletes arose, in which the difference between the groups was less than 0.05 except for the P-value of 0.135 between groups B and C. The groups that consumed the drinks made from extracts of *C. pilosula* and *A. senticosus* showed lower relative changes in blood lactate compared to the group that consumed the traditional drink. There was no significant difference between groups that consumed single-extract drinks, but the group that consumed a composite extract drink exhibited a lower relative change in blood lactate than those that consumed single-extract drinks.

Upon examining the relative changes in blood lactate levels of the same group before and after training, the data presented in Table 2 indicate noteworthy findings. In the placebo group, there was no statistically significant

change in blood lactate levels before and after training. Conversely, both the single *Codonopsis pilosula* and single *Acanthopanax senticosus* groups demonstrated significantly lower relative changes in blood lactate after training. Moreover, the *Codonopsis pilosula* and *Acanthopanax senticosus* composite group exhibited an even more substantial reduction in the relative change in blood lactate after training.

The maximum oxygen uptake of the four groups before and after training is shown in Table 3, and the detailed data will not be repeated. It can be seen from Table 3 that before training, there was no significant difference in maximum oxygen uptake among the four groups of athletes. After training, there were differences in maximal oxygen uptake among the four groups of athletes, of which only the P-value of 0.255 between group B and group C exceeded 0.05, indicating an insignificant difference. The groups that consumed either single *C. pilosula* or *A. senticosus* extracts had higher maximum oxygen uptakes than that of the group that took the traditional drink, while there was no significant difference between the groups that used a single extract. The group that took the composite extract-contained drink had a significantly higher maximum oxygen uptake than those that took a single extract.

Comparing the maximum oxygen uptake of the same group before and after training, it is evident from Table 3 that there was no significant change in the placebo group before and after training. However, both the single *Codonopsis pilosulae* and the single *Acanthopanax senticosus* groups exhibited a significant improvement in maximum oxygen uptake after training. Notably, the *Codonopsis pilosulae* and *Acanthopanax senticosus* composite group demonstrated an even more pronounced increase in maximum oxygen uptake after training.

Table 2. Relative changes in blood lactate during long-distance running before and after training in four groups of athletes.

Time period	Group	Blood lactate (mmol/L)	P _{AB}	P _{AC}	P _{AD}	P _{BC}	P _{BD}	P _{CD}
Pre-training	A – The placebo group	9.7 ± 1.2	0.175	0.275	0.221	0.169	0.219	0.114
	B – The single <i>Codonopsis pilosula</i> group	9.6 ± 1.1						
	C – The <i>Acanthopanax senticosus</i> group	9.7 ± 1.0						
	D – The composite group	9.6 ± 0.9						
Post-training	A – The placebo group	9.6 ± 0.8	0.014	0.008	0.001	0.135	0.022	0.021
	B – The single <i>Codonopsis pilosula</i> group	9.1 ± 0.5*						
	C – The <i>Acanthopanax senticosus</i> group	9.1 ± 0.8*						
	D – The composite group	8.3 ± 0.3**						

* and ** denote $P < 0.05$ and $P < 0.01$ in the comparison within the same group before and after training, P_{ij} denotes the difference between groups i and j in the same period.

Table 3. Maximum oxygen uptake before and after training in four groups of athletes.

Time period	Group	Maximum oxygen uptake (mL/kg/min)	P _{AB}	P _{AC}	P _{AD}	P _{BC}	P _{BD}	P _{CD}
Pre-training	A – The placebo group	66.18 ± 2.35	0.195	0.352	0.211	0.269	0.119	0.232
	B – The single <i>Codonopsis pilosula</i> group	65.87 ± 1.88						
	C – The <i>Acanthopanax senticosus</i> group	66.32 ± 1.47						
	D – The composite group	66.87 ± 1.12						
Post-training	A – The placebo group	68.85 ± 3.25	0.004	0.018	0.011	0.255	0.018	0.017
	B – The single <i>Codonopsis pilosula</i> group	73.69 ± 2.58*						
	C – The <i>Acanthopanax senticosus</i> group	73.84 ± 2.19*						
	D – The composite group	77.19 ± 3.14**						

* and ** denote $P < 0.05$ and $P < 0.01$ in the comparison within the same group before and after training, P_{ij} denotes the difference between groups i and j in the same period.

Conclusions

This paper provides a concise overview of plant extracts and sports drinks, followed by an examination of the impact of sports drinks enriched with extracts of *C. pilosula* and *A. senticosus* on the long-distance running endurance of 40 athletes from the Track and Field Department of the School of Physical Education at the South-Central Minzu University. Long-distance running endurance indices were assessed both before and after long-distance running training. The following results were obtained. Initially, there was minimal variance in the mean heart rate during long-distance running among the four groups. After training, the groups receiving extract supplementation exhibited lower mean heart rates than the placebo group. Notably, the group receiving the composite extract demonstrated the most pronounced reduction in mean heart rate. The relative change in blood lactate showed no significant differences among the four groups before training. However, after training, the groups receiving extract supplementation displayed lower

relative changes in blood lactate compared to the placebo group. Notably, the group receiving the composite extract exhibited the most substantial reduction in the relative change in blood lactate levels. Initially, maximum oxygen uptake did not significantly differ among the four groups. However, after training, the groups receiving extract supplementation demonstrated higher maximum oxygen uptakes than the placebo group. Remarkably, it was found that the group receiving the compound extract exhibited the most significant increase in maximum oxygen uptake.

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