Food Research 8 (2) : 184 - 191 (April 2024)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Development of jujube matcha energy gel and its effect on physical endurance performance of young active subjects

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Article history:
Received: 17 December 2022
Received in revised form: 6 June 2023
Accepted: 8 December 2023
Available Online: 26 March 2024

Keywords:
Energy gel,
Jujube,
Matcha,
Antioxidants,
Physical performance

DOI:
https://doi.org/10.26656/fr.2017.8(2).628

Abstract

Energy gels are widely used as an ergogenic aid to enhance athletic performance. Most energy gels in the market contain mainly maltodextrin. Prolonged or high-intensity exercise can result in the formation of free radicals, oxidative stress in active muscle, and accelerated muscle fatigue which affect physical endurance performance. This study aimed to develop an antioxidant energy gel using jujube as the base ingredient. Jujube is rich in natural glucose, fructose, potassium, and ascorbic acid. The gel was fortified with 2.5% matcha powder with antioxidant properties. Other minor ingredients include whey protein and pectin. Sensory attributes of jujube matcha energy gel were evaluated by fifty panellists. The mean overall acceptability score of the energy gel was 6.94 out of 9 with an acceptance index of 77%. Jujube matcha energy gel contains 72.44% moisture, 16.30% carbohydrate, 7.72% protein, 1.33% fat, 2.21% ashes, and 108 cal/100 g. The energy gel exhibited a relatively high antioxidant activity with DPPH free radical scavenging activity of 83.26%, ferric reducing antioxidant power of 49.21 mg FE/g, total phenolic content of 29.36 mg GAE/g, and total flavonoids content of 7.54 mg CE/g. Twenty-meter beep tests were conducted to examine the effects of consuming jujube matcha gel on the physical performance of 10 active subjects (ages 18-25). Blood glucose, time to exhaustion, Borg rating of perceived exertion, and predicted VO_2max were recorded. Overall, subjects were found to endure longer in the 20-meter beep test after consuming jujube matcha gel with an 18% improvement in time to exhaustion as compared to the control.

1. Introduction

It is well-documented that exogenous carbohydrate feeding improves prolonged endurance exercise performance and/or capacity (Cermak and van Loon, 2013; Stellingwerff and Cox, 2014). The potential mechanisms for improved performance when fed carbohydrates during exercise are thought to be due to various factors including maintenance of plasma glucose levels and high carbohydrate oxidation rates (Coyle *et al*., 1986), muscle glycogen sparing (Tsintzas *et al*., 1995) and direct effects on the central nervous system (Carter *et al*., 2004).

Feeding of energy gels during prolonged cycling elevated blood glucose levels and enhanced subsequent performance (Kozlowski *et al*., 2021). Consumption of a carbohydrate-protein gel improved cycling endurance and prevented post-exercise muscle damage (Saunders *et al*., 2007). An intake of a rice energy gel could maintain blood glucose and lactate concentration which might be a benefit for the endurance athlete to improve sports performance (Tharnpichet *et al*. 2019).

Most energy gels in the market contain 80-90% maltodextrin. However, maltodextrin has been reported to impose some health concerns including spikes in blood sugar, suppresses the growth of probiotics, and may cause an allergic reaction (MedicineNet, 2020). The energy gels in the market may be enriched with caffeine, branched amino acids, minerals, or vitamins.

According to the study by Takahashi *et al*. (2014), oxygen consumption increased 200-fold above the resting level in active muscles during prolonged exercise. This condition would increase the production of free radicals and lead to oxidative stress which in turn caused exercise-induced muscle fatigue or damage and affected physical performance. Hence, the objective of the present study is to develop an antioxidant energy gel using jujube and matcha as functional ingredients. The effect of consuming the jujube matcha energy gel on physical performance will also be examined.

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eISSN: 2550-2166

Jujube fruits contain (per 100 g) 72.5 g of carbohydrates, 217 mg of potassium, and 218 mg of ascorbic acid (USDA, 2018). Fructose and glucose are the major sugars found in jujube (Pareek, 2013). Glucose molecules are readily absorbed and metabolized to provide instant fuel during vigorous exercise, while fructose co-ingestion with glucose may benefit athletes by maximizing carbohydrate availability during exercise and during acute post-exercise recovery (Fuchs *et al*., 2019). Potassium replenishes the electrolyte lost; while ascorbic acid serves as an antioxidant to reduce oxidative stress during strenuous exercise.

The jujube energy gel is fortified with matcha powder to further increase its antioxidant activity. Matcha is a distinct Japanese green tea rich in catechins. The green tea epicatechins, epigallocatechin gallate, epicatechin gallate, epigallocatechin, epicatechin, and the epimers, gallocatechin gallate, catechin gallate, gallocatechin, and catechin contribute to the antioxidant activity (Xu *et al*., 2007). Green tea extract has been demonstrated to enhance endurance capacity by stimulating lipid catabolism (Murase *et al*., 2005). The stress-reducing effect of theanine from matcha was proven to be beneficial for physical performance by Unno *et al*. (2018).

2. Materials and methods

2.1 Preparation of jujube matcha energy gel

A 200 g of dried jujube was boiled in 700 mL of water for 10 mins. Next, the jujube flesh was blended with jujube water at a ratio of 1:1. The main ingredients for the gel were 48% blended jujube flesh, 48% jujube water, 2.5% matcha powder, and 1% whey protein. Maltodextrin and pectin (each < 1%) were added to enhance gel formation. The mixture was homogenized at 7500 rpm for 20 mins. The homogenized mixture was then pasteurized at 90°C for 2 s. The mixture was then cooled down rapidly and kept refrigerated for gel setting and further analysis.

2.2 Sensory evaluation

Various sensory attributes of the energy gel were evaluated by 50 untrained panellists using a 9-point hedonic scale (1: dislike extremely to 9: like extremely). A briefing on the evaluation procedure and sensory attributes was given to the panellists. A 9-point hedonic scale is commonly used for affective sensory evaluation to determine the acceptability of a product. The Acceptance Index (AI) of gel was calculated using the formula: AI = (Mean overall acceptability score/9) × 100.

2.3 Physicochemical analyses

Proximate analysis of the jujube matcha energy gel was carried out according to AOAC Standard methods. Carbohydrate was determined by difference. For antioxidant activity, DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging capacity, total phenolics content (TPC), and total flavonoids content (TFC) of the energy gel were determined using UV-Vis spectrophotometer based on methods described by Lu *et al*. (2014). Ferric reducing antioxidant power (FRAP) assay was conducted by using the method described by Zhong and Shahidi (2015). Mineral analysis was done for potassium and sodium content by using Flame-AAS (Agilent Technologies, 2017) and Microwave Plasma-AES (Agilent Technologies, 2021), respectively. The colour profile of the energy gel was measured by using the Lovibond spectrocolourimeter. The pH values were determined in triplicate.

2.3.1 Preparation of energy gel extract

A 5 g energy gel sample was extracted with 50 mL of 70% methanol for 50 mins in an ultrasonic water bath at 48°C. The mixture was then centrifuged at 8000 rpm for 5 mins. The supernatant of the sample was separated in a tube. Excess methanol was evaporated by using a rotary evaporator to obtain energy gel extract. The extract was stored in the freezer until further analysis.

2.3.2 DPPH Assay

The scavenging activity of DPPH radicals was determined according to the methodology described by Lu *et al*. (2014). Briefly, the extract was diluted 25 times with distilled water. A 0.1 mL of sample extract and 3.9 mL of 0.06 nM DPPH solution were added into a test tube that was wrapped with aluminium foil. The mixture was then vortexed for 1 min and kept in the dark for 30 mins. Absorbance was read at 517 nm using a UV-Vis spectrophotometer against a prepared blank. The Radical scavenging activity, RSA (%) was calculated using the equation below:

$$\text{Radical scavenging activity, RSA (\%)} = \frac{(A_b - A_s)}{A_b} \times 100$$

Where A_S = the absorbance of the sample and A_b = the absorbance of the blank

2.3.3 Total phenolic content

A series of gallic acid standard solutions with different concentrations were prepared. A 0.4 mL of each standard solution was pipetted into a test tube and mixed with 2 mL of 10% Folic-Ciocalteu (FC) reagent. The mixture was incubated for 5 mins and then 1.6 mL of 7.5% sodium carbonate solution was added into each test

https://doi.org/10.26656/fr.2017.8(2).628

tube before incubation in a dark room for 1 hr. The absorbance of each standard solution was read at 765 nm using a UV-Vis spectrophotometer. A calibration curve was prepared by plotting the absorbance at 765 nm versus different concentrations of Gallic acid solution. For the TPC determination of the sample, 0.4 mL of the standard solution was replaced by 0.4 mL of diluted sample extract. The concentration of Gallic acid equivalent (GAE) was calculated by using the formula below:

$$\text{TPC (mg GAE/g)} = \frac{\text{R (mg/mL)} \times \text{Total Volume of sample extarct (mL)} \times \text{Dilution factor}}{\text{Weight of sample (g)} \times \text{Volume of sample extract used (mL)}}$$

2.3.4 Total flavonoid content

Catechin standard solutions with different concentrations were prepared. A 2 mL of distilled water was added into each 0.5mL standard solution in each test tube. A 0.15 mL of 5% sodium nitrite solution was added to each mixture and incubated for 5 mins after shaking. Then, 0.15 mL of 10% aluminium chloride was added to each tube incubated for 6 mins and vortexed. Next, 1 mL of 1.0M sodium hydroxide and 1.2 mL distilled water were added and incubated for 15 mins in dark conditions at room temperature. Then, the absorbance of each standard solution was read at 510 nm using a UV-Vis spectrophotometer. A calibration curve was prepared by plotting the absorbance versus different concentrations of catechin solution. For the TFC determination of the sample, the 0.5 mL of the standard solution was replaced by 0.5 mL of diluted sample extract. The TFC values were calculated by using the formula below:

$$\text{TFC (mg CE/g)} = \frac{\text{R (ppm)} \times \text{Total Volume of sample extarct (ml)} \times \text{Dilution factor}}{\text{Weight of sample (g)} \times \text{Volume of sample extract used (ml)} \times 1000}$$

2.3.5 Ferric reducing antioxidant power assay

A 3 mL of the freshly prepared FRAP reagent was mixed with 0.2 mL of the diluted sample thoroughly. An intense blue colour complex will be formed when the ferric tripyridyl triazine (Fe^{3+} TPTZ) complex is reduced to ferrous (Fe^{2+}) form. The absorbance at 593 nm was recorded after 30 mins incubation at 37°C. A blank was conducted. The calibration curve was prepared by plotting the absorbance at 593 nm versus different concentrations of $FeSO_4 \cdot 7H_2O$. The FRAP values were expressed as mg of ferrous equivalent Fe (II) per g of dry weight sample using the formula below.

$$\text{FRAP (mg FE/g)} = \frac{C \times V \times D}{W \times S}$$

Where C = ferrous (II) sulphate concentration (ppm), D = Dilution Factor, V = Volume of sample extraction (L), W = Weight of sample for extraction (g) and S = Volume of sample extract used (L)

2.3.6 Determination of potassium

A 0.5 g sample was transferred into a 50 mL beaker which was placed on a hot plate in the fume hood. 10 mL of the nitric acid-perchloric acid solution was added cautiously. The beaker was gently warmed until the sample was colourless. The digested sample was then centrifuged and filtered. The filtrate was diluted to the mark of 25 mL volumetric flask using distilled water. Next, five test tubes were labelled as blank, 1, 2, 3 and 4. A 4 mL of the sample solution was transferred to each of the five test tubes. A 0.2 mL of potassium chloride solution (1000 ppm) was added to tube 1, 0.3 mL to tube 2, 0.4 mL to tube 3, and 0.5 mL to tube 4. Then, 1 mL of distilled water was added to tube blank, 0.8 mL to tube 1, 0.7 mL to tube 2, 0.6 mL to tube 3 and 0.5 mL to tube 4. The solutions were aspirated into the flames. The flame-AAS analysis was then conducted on the samples and a graph was plotted. The instrumental readings were recorded for each solution.

2.3.7 Determination of sodium

A 1 g sample was added into each of the 3 clean porcelain crucibles and proceeded to ash in a muffle furnace for 5 hrs at 550°C. A 3 mL of concentrated nitric acid was added to the ashed sample and heated on a hot plate for 1 hr. The sample was stirred continuously during digestion by using a glass rod. The digested sample was then filtered into a small beaker and transferred into a 100 mL volumetric flask. The beaker was rinsed thrice with deionized water and poured into the volumetric flask. The flask was topped up with deionized water to 100 mL. The sample solution was further diluted 25× with deionized water. This sample solution was used for the sodium content analysis by Microwave Plasma Atomic Emission Spectroscopy (Agilent MS 4100 MP-AES). A series of different concentrations of sodium chloride solution was prepared with deionized water from a sodium chloride stock solution (10 ppm) for constructing a standard curve. The sodium content of the sample was determined by interpolating the absorbance reading of the sample solution against the standard calibration curve.

2.3.8 Colour measurement

A spectrocolourimeter was used to carry out colour analysis on the energy gel sample. Calibration was conducted on the spectrocolourimeter before analysis. The values of L*, a* and b* of the energy gel sample were recorded.

2.3.9 pH values

A pH meter was used to determine the pH value of the energy gel sample. Calibration was conducted on the

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pH meter before analysis.

2.4 Physical performance test

Permission to conduct the physical performance test was obtained from the Ethics Committee within TAR UMT. Twenty-meter beep tests were conducted to examine the effects of consuming jujube matcha gel on the physical performance of 10 healthy and active subjects. Subjects aged 18-25 and exercise at least 3 times a week were employed in this study. Subjects were required not to consume any kind of supplementation prior to testing and refrained from caffeine and alcohol consumption 24 hrs before each test in order to participate in this study. In addition, subjects were asked to fast for 10 hrs before each test to ensure the accuracy of data collection.

Subjects underwent 3 tests: preliminary test (control), test 1 (consumed commercial energy gel), and test 2 (consumed jujube matcha energy gel) for this study. The control is without taking any energy gels. For Test 1, a sachet of 32 g commercial energy gel Tri-Berry containing 450mg amino acid, 55 mg sodium, 20 mg caffeine, and 100 calories was given to each subject. Blood glucose, heart rate, time to exhaustion, Borg rating of perceived exertion, and predicted VO_2max before and after beep tests were recorded.

2.5 Statistical analysis

All the measurements were reported as the mean ± standard deviation (SD). The data were analyzed by using one-way analysis of variance (ANOVA) to determine the significant differences between treatments. Significance was defined at $p < 0.05$. The data analysis was performed using IBM SPSS software version 25.0.

3. Results and discussion

3.1 Sensory evaluation

The sensory attributes (colour, jujube flavour, matcha flavour, sweetness, bitterness, smoothness, and overall acceptability) of jujube matcha gel were evaluated by 50 untrained panelists using a 9-point hedonic scale (1: dislike extremely to 5: neither like nor dislike to 9: like extremely). Table 1 displays the mean scores of various sensory attributes of the jujube matcha energy gel. The mean score of all the sensory attributes was between 6 to 7, corresponding to “like slightly” to “like moderately” on the scale. The mean overall acceptability score of the energy gel was 6.94 out of 9 corresponding to “like moderately” and with an acceptance index of 77%. The colour of the jujube matcha energy gel has the lowest mean score of 6.06 with a minimum score of 4 and a maximum score of 8, indicating that most of the panellists are not in favour of the greenish colour of the energy gel, and the overall acceptability score could be negatively affected by the colour score. On the other hand, the scores for matcha flavour (6.70) and smoothness (6.94) are higher than that of other attributes, indicating that most panellists like match flavour and smoothness of the energy gel moderately. These two attributes are important contributors to the acceptance of the product.

Table 1. Mean score of sensory attributes of jujube matcha energy gel (n = 50).

Sensory attributes	Mean score
Colour	6.06±1.22
Jujube flavour	6.30±1.15
Matcha flavour	6.70±1.37
Sweetness	6.44±1.15
Bitterness	6.10±1.27
Smoothness	6.94±1.11
Overall acceptability	6.94±1.13

3.2 Physicochemical properties

The physicochemical properties of the jujube matcha energy gel are summarized in Table 2. Jujube matcha energy gel contains 72.44% moisture, 16.30% carbohydrate, 7.72% protein, 1.33% fat, 2.21% ashes, and 108 calories/100 g. Carbohydrate was obtained by difference.

Table 2. Physicochemical analyses of jujube matcha energy gel

Physicochemical Analysis	Amount
Chemical composition	
Moisture (%)	72.44±0.34
Carbohydrate (%), by difference	16.30
Fat (%)	1.33±0.07
Protein (%)	7.72±0.46
Ash (%)	2.21±0.04
Dietary fiber (%)	8.83±0.16
Sodium (mg/100 g)	85.83±0.83
Potassium (mg/100 g)	516.07±0.51
Antioxidant analysis	
Radical Scavenging activity (%)	83.26±0.64
FRAP (mg FE/g)	49.21±0.11
TPC (mg GAE/g)	29.36±0.01
TFC (mg CE/g)	7.54±0.10
pH value	5.09±0.01
Colour	
L*	22.70±0.10
a*	3.80±0.10
b*	17.70±0.10

Values are presented as mean±SD (n = 3). FE: Ferrous equivalent, GAE: Gallic acid equivalent, CE: Catechin equivalent.

https://doi.org/10.26656/fr.2017.8(2).628

Carbohydrate feeding has been shown to be ergogenic but according to Jeukendrup (2010), it was found that limitations to carbohydrate oxidation were in the absorptive process most likely because of a saturation of carbohydrate transporters. By using a combination of carbohydrates that use different intestinal transporters for absorption it was shown that carbohydrate delivery and oxidation could be increased. Studies demonstrated increases in exogenous carbohydrate oxidation rates of up to 65% of glucose: fructose compared with glucose only. The increased carbohydrate oxidation with multiple transportable carbohydrates was accompanied by increased fluid delivery and improved oxidation efficiency, and thus the likelihood of gastrointestinal distress may be diminished. Studies also demonstrated reduced fatigue and improved exercise performance with multiple transportable carbohydrates compared with a single carbohydrate. In the present study, jujube fruits which are rich in glucose and fructose are therefore chosen as the base ingredient for the development of the energy gel for optimizing energy fuelling.

Fructose and glucose are the main sugars found in jujube. Glucose molecules are readily absorbed and metabolized to provide instant fuel during vigorous exercise. Fuchs *et al.* (2019) reported that fructose co-ingestion with glucose increased the total capacity to absorb carbohydrates. Fructose can be used as an additional fuel source during exercise and as a substrate for liver glycogen repletion during post-exercise recovery. Therefore, fructose co-ingestion may benefit athletes by maximizing carbohydrate availability during exercise and during acute post-exercise recovery.

The jujube matcha energy gel contains 7.72±0.46% protein. The protein in jujube matcha gel partly comes from whey protein which is a good source of branched-chain amino acids (BCAAs). The BCAAs are a group of three essential amino acids: leucine, isoleucine, and valine (Holeček, 2018). The oxidation of amino acids, mostly BCAAs, provides 10–15% of the total energy required during prolonged exercise (Pasin and Miller, 2000).

Sodium and potassium in energy gels replenish the electrolytes lost during sweating and these minerals play a vital role in enhancing the endurance performance of athletes. Potassium functions in balancing the fluids and electrolyte levels in the body and fuels the muscle cells during exercise. According to Li *et al*. (2007), potassium was the predominant mineral in Chinese jujube. Previous research reported that the potassium contents in jujube ranged from 79 mg to 713 mg/100 g (Li *et al*., 2007; Al-Farsi and Chang, 2008). In the present study, jujube matcha gel was found to contain (per 100 g) 516 mg potassium and 85 mg sodium. The minerals were contributed mainly from jujube and partly from matcha powder. According to the USDA food composition database (USDA, 2018), sodium content is lower than potassium in jujube fruits, which aligns with the result obtained in this study.

Based on the US Patent publication of Mathewson (2005), the desired sodium content of the energy gels is in a ratio in the range of 0.4 to 1.2 parts of sodium to 100.0 parts of carbohydrate, while the potassium content of the gels is in a ratio in the range of 0.05 to 2.0 parts of the potassium to 100.0 parts of the carbohydrates for replenishing electrolytes lost during exercise and for facilitating intestinal reabsorption of fluids. According to the author, the inclusion of electrolytes in the above-stated range gives the following advantages over traditional energy gels: superior electrolyte replacement benefits, superior fluid retention benefits, hyponatremia prevention, and superior intestinal reabsorption of fluids during exercise. In this study, the sodium content of jujube matcha gel was 85 mg in 16.3 g of carbohydrates, equivalent to 0.52 parts of sodium to 100.0 parts of carbohydrates, which is within the recommended range. The jujube matcha gel contains 516 mg potassium in 16.3 g carbohydrate, equivalent to 3.0 parts potassium to 100.0 parts of carbohydrate which is slightly higher than the recommended range.

The jujube matcha energy gel exhibited a relatively high antioxidant activity with DPPH free radical scavenging activity of 83.26%, ferric reducing antioxidant power of 49.21 mg FE/g, total phenolic content of 29.36 mg GAE/g, and total flavonoids content of 7.54 mg CE/g (Table 2). Al-Farsi and Chang (2008) reported jujube fruits to contain (per 100 g) 239 mg total phenolic content, and 122 mg total flavonoids content. The reducing antioxidant power of the energy gel is mainly attributed to the presence of ascorbic acid in jujube.

Matcha powder is rich in antioxidants such as catechins, epigallocatechin, epigallocatechin 3-gallate, epicatechin gallate, gallocatechin gallate, and epicatechin. The stress-reducing effect of theanine from matcha was proven to be beneficial for physical performance (Unno *et al.,* 2018). Antioxidant supplements have been reported to improve physical performance through different mechanisms. Antioxidants reduce oxidative stress via free-radical scavenging; support faster recovery from sports injuries via anti-inflammation; reduce muscle fatigue via reduction of kinase and lactic acid levels; and increase the length of workout via enhancement of lipid metabolism (Wolf *et al*., 2010).

https://doi.org/10.26656/fr.2017.8(2).628

The L*, a*, b* values of jujube matcha energy gel were 22.70, 3.80, 17.70, respectively. L* represents lightness from black to white on a scale of 0 to 100; while positive values of a* and b* represent red and yellow, respectively; and negative values of a* and b* represent green and blue, respectively. The jujube matcha gel exhibited an opaque and dark greenish-red colour, primarily attributed to the red jujube fruit and the green matcha powder. The colour of the gel scored 6.06, corresponding to "like slightly" by the panellists. The slightly acidic pH of 5.09 gives the jujube matcha energy gel an overall sweet-and-sour taste which is acceptable by the panellists.

3.3 Physical performance tests

Twenty-meter beep tests were conducted to examine the effects of consuming jujube matcha gel on the physical performance of 10 active subjects (ages 18-25). The effect of consuming jujube matcha gel or commercial gel on physical performance was compared and the results were reported as the percentage of improvement based on the control (Table 3).

Table 3. Percentage of improvement on physical performance.

Test	Commercial energy gel (%)	Jujube matcha energy gel (%)
RPE level	11.46[a]	11.77[a]
Time to exhaustion	17.29[a]	18.73 [a]
Predicted VO_2max	9.76[a]	11.00[a]

Values presented are mean of triplicates. Values with different superscripts within the same row are significantly different ($p<0.05$). RPE: Rating of Perceived Exertion.

The Borg Rating of Perceived Exertion (RPE) is a method for measuring the physical activity intensity level of subjects. It depends on the physical sensations experienced by the subjects during physical activity, including increased respiration or breathing rate, increased sweating, and muscle fatigue. The RPE Level is directly proportional to the exertion of the subjects and the hardness of the exercise. RPE levels from 6 to 11 indicate the exercise is light, RPE levels from 12 to 16 indicate that the condition of the exercise is moderately hard, and RPE levels from 17 to 20 correspond to the person's fatigue the exercise is hard (Williams, 2017).

The mean value of the RPE level of subjects during the preliminary test (without consuming any gels) was rated 17.0±1.1, indicating that the beep test was hard for the subjects without consuming the energy gel before the beep test. This corresponded to the condition that the subjects could continue the beep test but must push themselves hard and experience fatigue. RPE levels for subjects consuming commercial gel and jujube matcha gel were 15.1±2.0 and 15.0±1.3, respectively. These values corresponded to the condition that the exercise was moderately hard and the subjects felt heavy but were still able to continue. The statistical analysis results showed that consumption of commercial gel and jujube matcha gel had an improvement of 11.46% and 11.77%, respectively, although there were no significant differences between the two treatments. The improvement could be attributed to the ingestion of gels which served as energy boosters for the subjects during the beep test.

The time to exhaustion of subjects is directly proportional to their levels of beep test succession. Time to exhaustion for subjects consuming commercial gel (8.92±1.11 mins) and jujube matcha gel (9.05±7.28 mins) was significantly longer than that of the control (7.65±1.05 mins), representing the percentage of improvement of 17.29% and 18.73%, respectively. Losing fluids and electrolytes during prolonged exercise can reduce endurance, cause cognitive impairment, disrupt energy balance, accelerate fatigue, reduce aerobic capacity, and impair cardiovascular function (Kaidah *et al.,* 2020). Decreased electrolyte levels in body fluid have been associated with metabolic fatigue as well as neurological fatigue - fatigue in the muscles due to reduced working capacity of the neuromuscular system (Hornery *et al*., 2007). In the present study, ingestion of jujube matcha energy gels demonstrated an increase in time to exhaustion of subjects. Triplett *et al*. (2010) reported that physical performance can be improved by ingestion of a carbohydrate solution containing glucose and fructose which provide intense energy to subjects during cycling. Furthermore, natural antioxidants present in jujube matcha energy gel could reduce oxidative stress, muscle fatigue or muscle damage, which otherwise can disturb exercise performance (Takahashi *et al*., 2014).

VO_2max is the maximum rate of oxygen consumption of muscles while working at full capacity. Maximal oxygen uptake reflects the capability of the cardiovascular system to transport oxygen to the working muscles. Therefore, individuals with higher VO_2max values have been regarded as possessing "endurance fitness" or "cardiorespiratory fitness" (Scribbans *et al*., 2016). The beep Test was used to predict the VO_2max based on the succession level of the beep test and shuttle score from the 20-meters shuttle run test as it has been claimed that there was a strong correlation between running performance and VO_2max (Scribbans *et al*., 2016). In this study, the predicted VO_2max for subjects who consumed commercial gel (44.70±3.55 $mL.kg^{-1}.min^{-1}$) and jujube matcha gel (45.25±3.87 $mL.kg^{-1}.min^{-1}$) were significantly higher than that of the control (40.82±3.64 $mL.kg^{-1}.min^{-1}$), corresponding to an improvement of 9.76% and 11.00% in beep test,

https://doi.org/10.26656/fr.2017.8(2).628

respectively. However, there was no significant difference between the two treatments.

4. Conclusion

Jujube matcha energy gel with acceptable sensory quality was developed. The energy gel contained natural carbohydrates, high potassium content, and exhibited 83% radical scavenging activity. In this study, consumption of jujube matcha gel demonstrated some improvement in the physical performance of the subjects during 20-meter beep tests. The effects of jujube matcha energy gel on the performance of other physical tests should be explored further.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The authors would like to thank Tunku Abdul Rahman University of Management and Technology for their financial and technical support.

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