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The potential of Curcuma extract to alleviate muscle damage in amateur soccer players

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ABSTRACT

Compounds with high bioactive are commonly used as a nutritional approach for accelerating muscle damage recovery after strenuous exercise. There are still inconsistent results of post-exercise antioxidant supplementation on the circulating muscle damage biomarker. This study aimed to examine the effect of post-exercise Curcuma extract supplementation in ice cream on muscle damage and inflammatory markers in amateur soccer players. Male amateur soccer athletes (aged 14 – 18 years) participated in a randomized double-blind placebo-controlled study under two conditions: control group (n = 10) and treatment group (n = 10). The treatment group was treated with Curcuma extract ice cream (250 mg/100 g) for 21 days. Blood samples were drawn before training, considered baseline, and 3 h after training on day 21. The level of creatine kinase, IL-6, haemoglobin (Hb), and lactic acid were quantified. There was a significant decrease in creatine kinase change in the treatment group compared to the control group (p <0.05). No change in IL-6 and Hb levels in the treatment group. Lactic acid decreased by 16.3% from baseline in the treatment group (p <0.05). Curcuma extract ice cream potentiates to ameliorate exercise-induced muscle damage.

Keywords: Curcuma extract, inflammation, muscle damage, soccer, exercise

INTRODUCTION

Muscle damage mediated by inflammation is a key feature in response to exercise **[1]**. Creatine kinase is an enzyme found at a high level under high energy demands (i.e., after the high intensity of exercise) and is considered an indirect indicator of muscle damage **[2]**. Exercise-induced muscle damage stimulates the bone marrow to release immune cells, which can express cytokines such as interleukin-6 (IL-6). A marked increase in IL-6 level was observed immediately after a soccer game in elite competitive-level players **[3]**. Inflammation in response to exercise-induced muscle damage can be featured by pain feelings **[4]** that may subsequently decrease athlete performances. A nutritional approach has been conducted to alleviate inflammation-associated muscle damage after exercises, such as ginger (*Zingiber officinale*), ginseng (*Panax quinquefolium*), and Curcuma **[5]**. The inflammation phase and degree of oxidative stress in response to exercise-induced muscle damage are interrelated. Increasing oxidative stress levels indicated by excessive free radical production have been widely investigated and considered a signal to activate the immune system **[6]**. The production of free radicals after exercise is required to induce muscle rejuvenation.

On the other hand, the magnitude of oxidative stress reflects the degree of exhaustion state **[7],** and athletes need to accelerate muscle recovery. The overwhelming free radical could be ameliorated by exogenous antioxidants that help the body to produce endogenous antioxidants such as superoxide dismutase (SOD), glutathione peroxidase (GPx), and catalase **[8]**. Exercising muscle in high intensity produces lactate in muscle and consequently releases it into circulation. Blood lactate has been reported to elevate in the first 15 min during a soccer match and remained high throughout the game **[9]**. Antioxidant supplementation was previously reported to lower blood lactate after performing maximal aerobic exercise in amateur athletes **[10]**. Since the soccer game requires a combination of aerobic and anaerobic energy systems, evaluating the antioxidant supplementation effect in soccer athletes is required. Curcumin is an antioxidant substance in Curcuma and has been reported for its antioxidant capacity. The antioxidant capacity in curcumin is better than other components, such as *demetoksicurcumin* and *bisdemetoksicurcumin.*

Additionally, curcumin has an efficient reaction with superoxide radicals and lipid antioxidants, and the response leads to superoxide catalytic degradation, which curcumin represents as a SOD **[11]**. Supplementation in food products may increase acceptability. Ice cream is one of the products with a broad market segment, and every single person, regardless of age, is fond of it. The intervention of curcumin supplementation on the exercise-induced oxidative stress marker in recreationally participants has been previously reported **[12]**. The study revealed that significantly lower serum derivatives of reactive oxygen metabolites after exercise were observed in the curcumin group.

Furthermore, a systematic review and meta-analysis have recently reviewed the effect of curcumin supplementation on inflammatory markers and muscle damage in sedentary participants **[13]**. Nevertheless, the effect of curcumin supplementation post-training on the circulating muscle damage, inflammatory marker, lactate, and haemoglobin in soccer athletes has not been investigated. Therefore, this study aimed to examine the effect of Curcuma extract in the ice cream form supplementation on creatine kinase, IL-6, lactate, and haemoglobin.

Scientific Hypothesis

We hypothesized that post-training Curcumin intervention alleviated muscle damage-related to training, indicated by a significant difference in circulating creatine kinase and inflammatory markers.

MATERIAL AND METHODOLOGY

Samples

Blood samples were taken in the prior study before subjects conducted the training. The Curcuma extract ice cream was given daily for 21 days after subjects ran 1 km consisting of a repeated sprint, six maximal 15-m runs with a 30-s recovery, an intermittent endurance test (IET) consisting of forty 15-s bouts of high-intensity running interspersed by 10-s bouts of low-intensity running. At the end of the study, at least 3 h after training, the blood samples were taken to assess IL-6 and creatine kinase.

Chemicals

Human IL-6 Elisa Kit (Elabscience, USA) and human creatine kinase (Elabscience, USA) were used in this study.

Animals and Biological Material

The raw Curcuma was purchased from the local market Purworejo, Semarang Province, Indonesia, where well-recognized for having a high-quality Curcuma.

Laboratory Methods

Based on the previous study, the ice cream composition had 11% fat and 15% sugar **[14]**. The flowchart for making ice cream showed in Figure 1. In brief, the same ripe of Curcuma rhizome was selected. The selected Curcuma rhizome was sliced ±5 – 7 mm thickness after washing. The Curcuma rhizome was dried in the oven at 50 °C until the water content was 10% and was filtered using a 40-mesh filter to obtain the Curcuma powder. The ingredients (milk, Curcuma powder, sugar, Carboxymethyl cellulose) were mixed, then lemon juice (3 mL/100 g ice cream) and cinnamon (10 mL/100 g ice cream) were added after it was heated at 80 °C for 20 min. The final compound (Figure 2) was kept at the freezer temperature.

Description of the Experiment

The inclusion criteria of this study were male, 14 – 18 years, no acute and chronic diseases identified, Hb level ≥13 g/L, nutrition status normal (BMI ranged from 18.5 – 25.0 kg/m^2), no coffee, no alcohol, and no drugs consumption, no smoking, no vitamin, and other supplements consumption at least two weeks before this study was conducted, no additional exercise except the programmed exercise. Written informed consent was obtained from all participants. All of soccer athletes in Pusat Pendidikan dan Pelatihan Pelajar (PPLP) Semarang (Indonesia) became the subject in this study (n = 20). Participants were divided into two groups: the control group (n = 10), treated with ice cream without any Curcuma extract supplementation, and the treatment group (n = 10), treated with Curcuma ice cream. The confounding variable in this study (the antioxidant-sourced food) was controlled by recording the athletes' dietary intake. The ice cream selected in the present study was the ice cream contained 250 mg of Curcuma since we considered the sensory evaluation result of this study (unpublished data). The procedure of this study was according to the guidelines laid down in the Declaration of Helsinki and has been reviewed and approved Bioethical Commission of Research of Faculty of Medicine Universitas Sultan Agung, Semarang, Indonesia with No. 208/IV/2018/Komisi Bioetik and registered at ClinicalTrials.gov ID: NCT04439981. Daily subject intakes during the study were recorded in the recall form (data not shown).

The selected Curcumin rhizome

↓

Washed and sliced in ± 5 – 7 mm thickness

↓

Dried in the oven at 50 °C up to Curcumin had 10% of water content

↓

Filtered using 40 mesh filter

↓

Milk was mixed by the mixture of Curcumin powder, sugar, and Carboxymethyl cellulose

↓

Heated up to 80 °C for 20 min

↓

Lemon juice was added 3 mL/100 g ice cream

↓

Cinnamon water was added 10 mL/100 g ice cream

↓

The compound was freeze in the freezer temperature

Figure 1 The workflow of the Curcuma ice cream-making process.

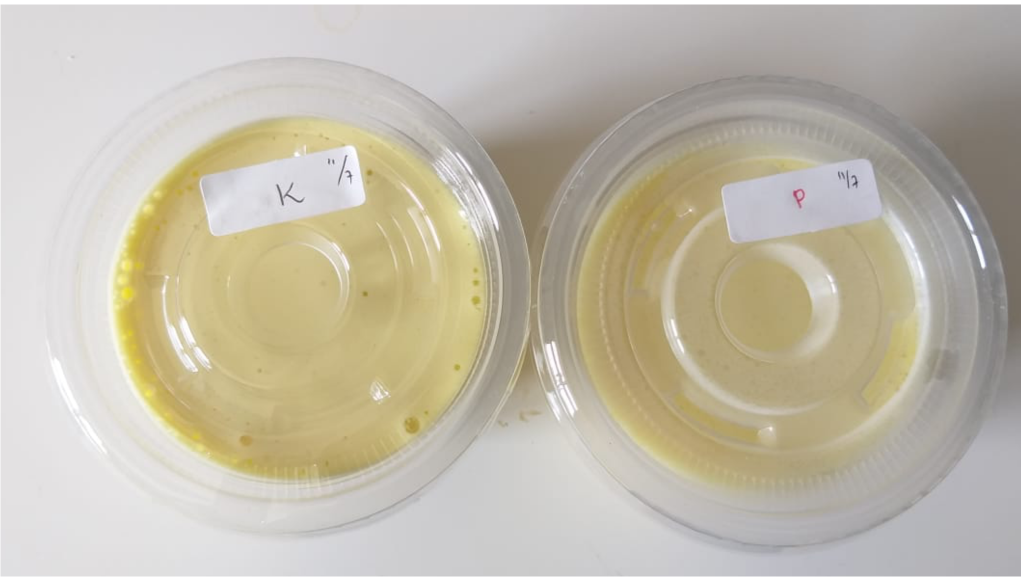

Figure 2 The representative ice cream consumed by the control group (left) and intervention group (right). The physical appearance of ice cream in the control and intervention groups was identical.

Statistical Analysis

Statistical analyses were performed using SPSS software for IBM 27.0 version. Since the data are normally distributed (indicated by *p* >0.05 on the Shapiro-Wilk test), parametric tests were performed. The comparison between groups was analysed by ANOVA followed by an LSD post-hoc test to assess the Curcuma ice cream. For the supplementation effect on the haematological biomarkers, the comparison before and after the intervention was analysed using paired t-test. At the same time, the comparison between the group was analyzed by an independent t-test. The data were expressed as mean ±SE and were considered significant at 95% CI (*p* <0.05).

RESULTS AND DISCUSSION

To our knowledge, this study was a novel study giving curcumin supplementation after training amateur soccer athletes. Curcumin has been comprehensively reported to significantly enhance total antioxidant capacity with a significant effect in humans **[15]**; therefore, the present study aimed to answer whether the antioxidant supplementation post-exercise in the fatigue indicated by circulating creatine kinase. The present study has three main findings: 1) 250 mg of Curcuma/100 g ice cream decreased lactic acid level significantly by 16.3%. 2) The Curcumin content in this study may not be sufficient to reduce fatigue biomarkers indicated by circulating creatine kinase.

The effect of Curcuma extract ice cream on muscle damage

The baseline characteristics of the participants are summarized in Table 1. Decreasing creatine kinase after 21 days of intervention of curcumin supplementation was observed by 10%.

Table 1 Baseline characteristics of participants.

Variables	Control group (n = 10)	Treatment group (n = 10)	*p*-value
Age (y)	16.2 ±0.2	16.8 ±0.9	0.75
BMI (kg/m^2)	22.1 ±2.5	21.1 ±1.9	0.61
Haemoglobin (g/L)	13.5 ±1.6	14.1 ±2.5	0.89

Note: Data are expressed as mean ± SD; BMI – Body Mass Index; data are analysed by independent t-test.

Curcuma extracts ice cream, as seen in Table 2, reduced creatine kinase levels at the end of the study by -32.50 ±73.56 U/L. The creatine level of the treatment group differed significantly from the creatine level of the control group (p <0.01). Creatine kinase has widely increased significantly after muscle contraction, indicating exercise-related muscle damage **[2]**, **[16]**. Increasing creatine kinase related to strenuous exercise **[2]**, **[17]** is mediated by the inflammation phase **[18]**, **[19]** indicated by neutrophil infiltration as a first immune response to muscle damage **[20]**, **[21]**. The sport of soccer requires a combination of energy from aerobic and anaerobic energy systems **[22]**, and antioxidant supplementation has been highlighted as a method to accelerate recovery after training **[23]**. The previous studies showed that antioxidant supplementation, either in bioactive or vitamins, lowered creatine kinase, which may be due to endogenous antioxidant increases **[24]**, **[25]**, **[26]**. Even though the intervention of post-training antioxidant supplementation slightly decreased creatine kinase, curcumin potentiates to alleviate circulating creatine kinase when it is provided in a higher concentration.

The effect of Curcuma extract ice cream on inflammation

Even though there was no significant difference between the two groups at the end of the study, curcumin extract ice cream decreased IL-6 level in the treatment group by 0.007 ±0.03 pg/mL (Table 2). IL-6 is a standard inflammatory marker released by muscle due to muscle contraction and low muscle glycogen **[27]**, **[28]**. The mobilization of circulating IL-6 is seemingly time-dependent after exercise, which is still inconsistent compared to the previous study **[28]**. A previous study showed the circulating IL-6 returned to baseline the 1.5 h after a single bout of exercise **[29]**, indicating the rapid kinetic response of IL-6 to muscle damage. The concentration of circulating IL-6 depends on the intensity of training, which might lead to numerous folds from 5 to 100 folds, and it reaches a peak in 30 minutes after strenuous exercise **[30]**. We speculate the circulating IL-6 in the present study has returned to baseline since the blood draw was taken at least 3 h after training.

The effect of Curcuma extract ice cream on Hb

Table 2 shows an increasing level of Hb in the treatment group. In contrast, decreasing levels of Hb were observed in the control group. The difference in the haemoglobin level had a significant level between those two groups (p = 0.017). Hb on the sports field may be a crucial haematological biomarker to carry oxygen from the lungs to the tissue **[31]**, **[32]**, which is proportional to athletes' decreased performance **[33]**. Increasing demand for oxygen in the contracting muscle led to bulk blood flow into exercised muscle tissue to maintain a sufficient oxygen level **[34]**. Therefore, decreasing haemoglobin was observed after exercise **[35]**. This study resulted in the improvement of haemoglobin levels in the treatment group compared to the control group. Curcuma in the herb form with 30 mg/100 g has proven to maintain Hb to normal levels in animal experiments **[36]**. The present study used the lowest antioxidant content since we consider the preference of the participants based on the sensory acceptability of the Curcuma ice cream. Further examination is required asking whether Curcumin supplementation affects the muscle damage and inflammatory markers in skeletal muscle of soccer athletes since Curcuma supplementation potentiates to alleviate exercise-induced muscle damage. Sequential time analysis is required in a future study to delineate the magnitude change of the markers in response to Curcumin supplementation.

Table 2 Creatine kinase, IL-6, haemoglobin, and lactic acid level at the beginning and end of the study.

	Control Group	Treatment Group	*p*-value
Creatine kinase level (U/L)			
Before	157.60 ±29.98	317.20 ±243.36	0.009[b*]
After	253.40 ±133.79	284.70 ±196.63	0.971[b]
Difference	95.80 ±116.95	-32.50 ±73.56	0.010[b]*
p-value	0.037[a*]	0.203[a]	
IL-6 level (pg/mL)			
Before	0.508 ±0.76	0.159 ±0.05	0.739[b]
After	0.538 ±0.78	0.152 ±0.04	0.165[b]
Difference	0.030 ±0.06	-0.007 ±0.03	0.190[b]
p-value	0.139[a]	0.574[a]	
Haemoglobin level (g/dL)			
Before	15.35 ±0.80	15.75 ±1.21	0.393[b]
After	14.98 ±0.67	15.98 ±0.99	0.017[b]*
Difference	-0.37 ±0.37	0.23 ±0.62	0.017[b]*
p-value	0.012[a*]	0.268[a]	
Lactic acid level (mmol/L)			
Before	3.73 ±0.47	3.25 ±0.90	0.152[b]
After	4.76 ±2.33	2.72 ±0.68	0.015[b]*
Difference	1.03 ±2.15	-0.53 ±0.79	0.050[b]*
p-value	0.185[a]	0.06 [a]	

Notes: * – indicates data significantly different (p <0.05); [a] – data were analysed by paired t-test; [b] – data were analysed by independent t-test; data are presented as mean ±SD. IL-6 – interleukin-6.

The effect of Curcuma extract ice cream on lactic acid

As shown in Table 2, the level of lactic acid was significantly decreased in the treatment group (-0.53 ±0.79; p = 0.06), but there was an increasing level of lactic acid in the control group. There was also a significant difference between the two groups at the end of the study (p = 0.015). Blood lactate level can be used to predict exercise intensity **[37]**, evidenced by the proportional increases of blood lactate concentration as the increase in work rate **[38]**. This study highlighted the increase of lactic acid levels in the control group by 27.6% from baseline. Lactate can be considered as an intracellular shuttle that provides the raw material for ATP resynthesis in mitochondria during the high physical effort of exercise **[39]**. The reduction of lactic acid in the intervention group may be explained by increasing lactate clearance through lactate dehydrogenase (LDH). Therefore, lactate can be converted into pyruvate **[40]**. The potential ability of curcumin to maintain the redox state via ameliorating reactive oxidative species (ROS) in skeletal muscle damage cannot be excluded. Strenuous muscle contraction generates free radicals **[41]** as a signal to recruit neutrophils from bone marrow **[42]**. Curcumin can be considered an antioxidant as β-diketone groups can enhance the activity of catalase, SOD, and GPx, which act as endogenous antioxidants **[43]**. In this study, the antioxidant activity has been observed and may potentiate to stimulate endogenous antioxidant release.

CONCLUSION

Curcumin extract ice cream (250 mg/100 g) has the potency to reduce muscle damage in soccer athletes after conducting 21 day-strenuous training. Curcuma extract ice cream intervention might suppress the inflammation phase following exercise. We postulate that the decrease in lactic acid in the intervention group relates to the amelioration of free radicals from exercise. The present study brings the novel for the long-term effect on muscle recovery after training. Further research is required to see the effectiveness of the acute impact to see an inflammatory response after training.

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Conflict of Interest:

The authors declare no conflict of interest.

Ethical Statement:

The study protocol has been reviewed and approved by Bioethical Commission of Research of Faculty of Medicine Universitas Sultan Agung, Semarang, Indonesia with No. 208/IV/2018/Komisi Bioetik. The present study was also registered at ClinicalTrials.gov identifier: NCT04439981.

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