Send Orders for Reprints to reprints@benthamscience.ae

The Open Sports Sciences Journal, 2017, *10*, 151-159

BENTHAM OPEN

CrossMark

The Open Sports Sciences Journal

Content list available at: www.benthamopen.com/TOSSJ/

DOI: 10.2174/1875399X01710010151

RESEARCH ARTICLE

Effects of Banana (*Musa Sapientum* Linn) Consumption for Physical Strength, Metabolic Response, Oxidative Stress, Lipid Profiles, and Interleukin-23 in Healthy Men: A Preliminary Study

Jirakrit Leelarungrayub[1,*], Arisa Parameyong[1], Wichai Eungpinichpong[2] and Jakkrit Klaphajone[3]

[1]*Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai 50200, Thailand*

[2]*Research Center in Back, Neck, and Other Joint Pain and Human Performance, Khon Kaen University, Khon Kaen, 40002, Thailand*

[3]*Department of Rehabilitation Medicine, Faculty of Medicine, Chiang Mai University, Chiang Mai 50200, Thailand*

Received: March 16, 2017 Revised: June 21, 2017 Accepted: June 23, 2017

Abstract:

Background:

Banana (*Musa sapientum* L.) is one of the many fruits that is well consumed in many countries having lots of benefits on health; however there are less evidences regarding physical performance, oxidative stress, metabolic, lipid, and pro-inflammatory cytokines in human. The aim of this study was to evaluate the effects of four weeks of banana consumption on physical strength, metabolic response, oxidative stress status, lipid profiles, and interleukin-23 in healthy men.

Methods:

Thirty healthy men were included in two week control and four week consumption periods. The parameters were evaluated by physical strength (back-leg strength, hand grip, and quadriceps strength), metabolic response to a cycling exercise test ((directed oxygen consumption (VO_2), exercise time, respiratory exchange ratio (RER), ventilatory threshold (VT)), blood antioxidant status ((total antioxidant capacity (TAC), glutathione (GSH), malondialdehyde (MDA)), lipid profiles ((triglyceride, cholesterol, high density lipoprotein (HDL)), and plasma interleukin-23 (IL-23). These measures were evaluated in two times for 2 weeks before the continuous consumption of pulp from two ripe bananas, morning and evening for 4 weeks.

Results:

The results showed no statistical difference in parameters over the two week control period. After four weeks of banana consumption, the back strength, exercise time, RER, and VT were significantly improved. TAC and GSH levels were increased and MDA, triglyceride, cholesterol, and IL-23 were reduced significantly when compared to the control period.

Conclusion:

These preliminary results suggest that banana supplementation involves some physical strength, oxidative stress, lipid profile, and IL-23 levels in healthy human.

Keywords: Banana, Physical strength, Oxidative stress, Metabolic, Lipid profiles, IL-23.

* Address correspondence to this author at the Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai 50200, Thailand; Tel: (+66) 053936072; Fax: (+66) 053936042; E-mail: donrawee.leela@cmu.ac.th

BACKGROUND

***Musa sapientum* L. (Banana)** is a tropical fruit grown in many countries of the world [1]. In Thailand, three types of bananas, or dessert bananas, are popular; *i.e.* Kluai Khai, Kluai Hom Khiew, and Kluai Nam-Wa. At present, the consumption of many fruits, including bananas, has increased, due to their nutritional and therapeutic effects. According to the studies of Saura-Calixto and Goni in 2006 [2], phytochemical compounds within many fruits such as carotenoids, phenolics, flavonoids, and vitamin C and E clearly have potential benefits for human health. Previous study showed that banana contains about 74% water, 53% carbohydrates, 1% proteins, 0.5% fat, and 2.6% fiber. In the process of ripening, the starches are converted to sugars; and a fully ripe banana has only 1-2% starch and 51% non-starch polysaccharides [3]. In addition, many parts of the banana are used in Thai traditional medicine. For example, the unripe fruit is used to treat diarrhea, and the ripe fruit is used as a tonic agent [4], including for treating gastric ulcer, hypertension, diarrhea, dysentery, and diabetes [5]. Previous report presented its benefits for anti-depression, preventing anemia, blood pressure control, and promoting the metabolic rate in conditions of stress [6]. Moreover, it has also shown to have significant changes on the lipid profile, muscle and liver glycogen, and enzyme activity as well as nitric oxide (NO) activity inhibition. Interestingly, Muschimapura and co-worker (2014) reported that a single administration of banana extract lengthened the swimming time in rats [7]. From the overall review of bananas, there are many benefits on health being related to delay in ageing process [8]. Thus, this pilot study evaluated the effects of 4 weeks of banana consumption on physical strength, metabolic response to an exercise test, oxidative stress status, lipid profiles, and pro-inflammatory interleukin-23 cytokine in sedentary men.

MATERIALS & METHODS

Study Design and Recruitment of participants

This research protocol was approved by the Human Ethics Committee Review Board following the Declaration of Helsinki in 1995 at the Faculty of Associated Medical Sciences, Chiang Mai University, Thailand (Ethical Approval Number 092E/53). Fifty healthy sedentary males aged between 18 and 24 years, with a body mass index (BMI) in the required normal range [18.0-24.9 kg/m^2, according to World Health Organization (WHO) and International obesity task force], were included from volunteer students in the main campus at Chiang Mai University. This study design was proposed to be limited to non-athletes or those exercising regularly for less than 3 days per week, therefore 12 males were excluded from 50 volunteers. Informed consent was obtained from all 38 volunteers before enrolling them in the study. During six weeks of studytheir regular activities, such as diet and behavioral aspects, were constantly controlled, including taking supplementary multi-vitamins or alcohol and any exercise was inhibited for eliminating the confounding factors. Moreover, all volunteers were also screened for inclusion into this research by a physician using hospital records and physical examination.

Experimental Design

For prevention of the less confidential results, all 38 healthy volunteers were not randomly divided into control and supplement groups, thus all volunteers were included into both control and supplement periods. Then, the program design was divided into two periods: 2 weeks of control and 4 weeks of consuming ripe bananas. The bananas were purchased from a local market in Chiang Mai Province. The bananas were purchased from the same orchard and had ripened within one week from the market. The pulp of two bananas was consumed after breakfast and dinner every day for 4 weeks. This study was designed with two banana pulps because previous recommendation from the World Health Organization (WHO) indicated the limitation of consumption of fruits and vegetables of at least 400 g/d [9]. One banana pulp is approximately 70-100 g, thus two banana pulps were selected to be consumed in morning and evening. There the weight of bananas was approximately 400 g daily. All parameters, *i.e.* physical strength (hand grip, back-leg, and quadriceps strengths), metabolic response to a cycling exercise test (exercise time, direct VO_2, respiratory exchange ratio (RER), ventilatory threshold (VT)), oxidative stress status (total antioxidant capacity (TAC), glutathione (GSH), and malondialdehyde (MDA)), lipid profiles (triglyceride, cholesterol, and high density lipoprotein (HDL)), and interleukin-23 (IL-23) were evaluated three times before (week 0 and week 2) and after 4 weeks of banana consumption (week 6).

Physical Strength Assessment

Hand grip strength was evaluated using a hand-held dynamometer (Chatillon DMG-250, USA). The procedure of hand grip strength followed the American College of Sport Medicine (ACSM) guideline (2008) [10], whereby the

standing test position had a grip bar adjusted to fit in the volunteer's hand. The second joint of the fingers was fitted under the handle of the dynamometer's handgrip. Before testing, the handgrip was set parallel to the side of the body, with arms slightly flexed. Three repeated maximally squeezes were performed and the highest squeeze force in kilograms was selected.

Back-leg strength was tested by standing upright on the floor. With arms straight down, the center of the bar was held in both hands with palms faced in toward the body. Before pulling up, the chain was adjusted until the knee was bent by approximately 10 degrees, and the back bent slightly forward. The head was to be maintained at an upright position, with eyes looking straight ahead, while the arms were kept straight and were not permitted to bend back. Three maximal pull ups were performed, and the highest force was noted in kilograms.

Quadriceps muscle strength was assessed using a handheld dynamometer (Chaillon DMG-250, USA). Volunteers were positioned in a test chair, with a hip angle of 90 degrees, and knee angle set at 30 degrees vertically. During the test, the trunk, hips, and thighs were strapped down to the chair to avoid involuntary movements. An individual landmark for placing the hand-held dynamometer at the antero-inferior region of the leg was calculated from the distance between the tuberosity and superior aspect of the lateral malleolus, multiplied by 0.6 [11]. Three repeated maximal static knee extensions were performed, and the highest force was selected.

Metabolic Response Assessment

The metabolic response to the cycling exercise test performed on a stationary bicycle was evaluated in all volunteers by the GE's Case® Exercise Testing System; MedGraphic (USA). Eighty percent of maximal heart rate (220-age) was set up at the end of the test. Direct VO_2 was analyzed automatically by the Breeze Suit Software program, using a breath-by-breath technique. When exercise was stopped, the total time of cycling, VO_2, VT, and RER were recorded. The criteria, precautions and other reasons for stopping the exercise followed the guideline of the ACSM (2004) [12].

Oxidative Stress Status, IL-23, and Lipid Profiles Assessments

The TAC of fresh plasma was assessed with the 2,2'-azino-bis 3-ethylbenzothiazoline-6-sulphonic acid (ABTS) decolorization method [13]. Total antioxidant capacity was calculated and presented by comparing the standard Trolox (Sigma) as mmol of Trolox per liter (mmol Trolox/L).

Whole blood GSH was assessed with 5,5'-dithiobis-(2-nitrobenzoic acid) (DTNB) following the previous protocol of Leelarungrayub *et al.* (2011) [14] and GSH was calculated and presented by comparing to the standard GSH (Sigma). The final unit of GSH was presented as mg GSH per one gram Hb.

Plasma MDA from lipid peroxidation was evaluated following the modified protocol of a previous study [14]. Plasma MDA (μmol/L) was determined by comparing with the standard Tetramethoxypropane (TMP) (Sigma).

IL-23 in plasma was detected by following the protocol guidelines of the Quantikine, Human IL-23 Immunoassay [15] as in a previous study [16]. The concentration of IL-23 was calculated by comparing with standard IL-23 (39-2,500 pg/mL).

Triglyceride, cholesterol, and high density lipoprotein (HDL) were evaluated using a Reflotron Plus machine (Roche Diagnostics Corp, Roche Cobas, Germany) at the AMS Clinical Service Central, Faculty of Associated Medical Sciences, Chiang Mai University, Thailand.

Nutrient Composition Analysis

The pulp of ripe banana was selected randomly in order to investigate the physical composition as percentage of humidity, total carbohydrate (CHO), protein, lipid and ash by the lyophilization technique: calculation, nitrogen analyzer, supercritical fluid extraction, and drying techniques, respectively, at the Health Research Institute, Faculty of Medicine, Chiang Mai University, Thailand. Nutrient compositions as L-ascorbic acid (Vitamin C), alpha-tocopherol (Vitamin E), and retinol acetate (Vitamin A) were analyzed using a High-Performance Liquid Chromatography (HPLC) following the previous protocols [17, 18], whereas total phenolic was evaluated by Folin reagent on spectrophotometry [19].

Statistical Analysis

All data were presented as mean ± standard deviation (SD). All parameters from three times evaluated were

statistically analyzed using the repeated measurement ANOVA, with the Least Significant Difference (LSD) test. Significance was set at $p < 0.05$.

RESULTS

From 38 sedentary participants who were inclusively recruited based on criteria, eight participants were excluded because of discontinuous supplement and loss of contact. Therefore, the final 30 healthy males were completely studied in this study. Regarding the characteristics of all 30 volunteers before the study, there were no statistical differences on white blood cells (WBC), red blood cells (RBC), hemoglobin (Hb), hematocrit (Hct), and platelet (Plt), including liver function enzymes as aspartate transaminase (AST) and alanine transaminase (ALT) ($p > 0.05$),in three time measurement (Table **1**).

Table 1. Characteristics, complete blood count and liver function test data of all 30 healthy men.

	Reference range	Control period		After 4 weeks consumption
		Week0	Week2	
Age	(years)	20.6 ± 1.45 (18 – 24)		
BMI	(Kg/m^2)	22.42 ± 4.10 (21.45 – 23.50)		
WBC	5-10 (10^3 /μL)	6.9 ± 1.3 (4.6-9.6)	6.6 ± 1.5 (3.8-11.2)	6.8 ± 1.7 (4.0-11.1)
RBC	3.8-5.3 (10^6 /μL)	5.4 ± 0.6 (4.1 – 7.0)	5.3 ± 0.4 (4.5 – 6.4)	5.5 ± 0.7 (4.19 – 6.5)
Hb	10-16 (gm/dL)	14.9 ± 1.1 (12.6 – 16.4)	14.8 ± 1.3 (13.0 – 16.2)	14.7 ± 0.9 (12.5 – 16.5)
Hct	36-50 (%)	46.6 ± 3.2 (39.2 – 51.9)	46.3 ± 2.7 (40.7 – 50.4)	46.0 ± 2.9 (37.8 – 5.4)
PLT	140-440 (10^3/μL)	292.9 ± 51.6 (37.9 – 78.6)	294 ± 51.8 (180 – 418)	273.5 ± 50.6 (172 – 423)
AST	10-42 (U/L)	27.2 ± 3.5 (12 – 35)	22.6 ± 2.7 (12 – 33)	23.6 ± 3.2 (13 - 31
ALT	10-40 (U/L)	26.8 ±2.7 (11 – 29)	22.8 ± 3.1 (10 – 22)	26.5 ± 2.6 (14 – 23)

Note; WBC = white blood cells, RBC = red blood cells, Hb = hemoglobin, Hct = hematocrit, Plt = platelet, AST = aspartate transaminase, and ALT = alanine transaminase. Values are mean (SD); range for each variable is indicated below in parameters.

Physical Strength

Table **2** shows no statistical difference in any strength parameter in the control period; hand grip, back-leg, and quadriceps ($p > 0.05$). After banana consumption twice daily for 4 weeks, hand grip and quadriceps strength did not improve when compared to week 0 and week 2 ($p = 0.67$ and $p = 0.79$). However, back-leg strength increased significantly when compared to both previous times either week 0 ($p = 0.045$), or week 2 ($p = 0.000$).

Table 2. Physical strength (hand grip, back-leg and quadriceps strength) of all 30 healthy men.

Physical Strength	Control period		After 4 weeks consumption
	Week 0	Week 2	
Hand grip strength (Kg)	41.41 ± 7.38 (26.50 – 62.00)	41.96 ± 7.18 (27.00 – 62.00)	42.87 ± 7.23 (31.60 – 64.00)
Back-leg strength (Kg)	140.50 ± 29.30 (90 – 200)	147.0 ± 29.60 (95.5 – 213..30)	161.75 ± 36.35 *, # (109.6 – 257.0)
Quadriceps strength (Kg)	10.10 ± 2.89 (5.00 – 15.30)	10.31 ± 3.07 (5.12 – 15.60)	11.01 ± 3.92 (5.10 – 20.40)

Values are mean ± SD; range for each parameter is indicated below in parentheses. * $p < 0.05$ when compared to week 0, and # $p < 0.01$ when compared to week 2. Data was statistical analyzed with a repeated measurement ANOVA and the Least Significant Difference (LSD) test.

Metabolic Response to the Cycling Exercise Test

The metabolic status test in Table **3** shows that all parameters from the cycling exercise test, such as exercise time, VO_2, RER, and anaerobic threshold at 80% of maximal heart rate (MHR), were not statistically different between week 0 and week 2 of the control period ($p = 1.00, 0.276, 0.548, 0.33$). However, a statistical improvement in exercise time (p

= 0.004), RER (p = 0.000), and VT (p = 0.000) was shown after banana consumption, whereas VO_2 did not show statistical difference (p = 0.294) when compared to the times in the control period (week 0 & 2).

Table 3. Metabolic response to the cycling exercise test in all 30 healthy men.

	Control period		After 4 weeks consumption
	Week 0	Week 2	
Cycling exercise time (minutes)	7.59 ± 1.13 (5.52 – 10.02)	7.43 ± 1.16 (5.49 – 10.05)	7.98 ± 1.14 # (6.08 – 11.12)
VO_2 (mL/Kg/min)	26.95 ± 4.94 (17.90 – 36.23)	27.28 ± 5.14 (18.12 – 36.20)	27.63 ± 4.69 (19.70 – 40.20)
Respiratory exchange ratio (RER)	1.06 ± 0.08 (0.91 – 1.25)	1.07 ± 0.06 (0.95 – 1.20)	1.12 ± 0.07 # (1.00 – 1.28)
Ventilatory threshold (min)	4.79 ± 1.01 (2.10 – 7.34)	4.85 ± 1.06 (2.42 – 7.41)	5.41 ± 1.12 # (3.25 – 8.07)

Values are mean±SD; range for each parameter is indicated below in parentheses. # p< 0.01 when compared to week 2 and week 0. Data was statistical analyzed with a repeated measurement ANOVA and the Least Significant Difference (LSD) test.

Oxidative Stress Status, Lipid Profiles, and IL-23

Table **4** shows the oxidative stress status, lipid profiles, and IL-23 in the control period (week 0 and week 2), and they did not change statistically (p > 0.05). TAC, GSH, and MDA were almost the same in week 0 and week 2 (p = 0.182, 0.393, 0.918). After 4 weeks of banana consumption, statistical increase in TAC (p = 0.000) or GSH (p = 0.000) was shown, and MDA concentration reduced (p = 0.000) when compared to both times of the control period. The mean values for the lipid profile screening in the control period were not statistically different and within reference ranges of triglyceride, cholesterol, and HDL. After 4 weeks of banana consumption, the levels of triglyceride and cholesterol reduced significantly (p = 0.001) when compared to week 2, whereas the HDL level was not statistically different as compared to the control period (p = 0.787). Finally, the results showed a statistical difference of the pro-inflammatory IL-23 cytokine parameter after consumption when compared to week 0 (p = 0.042) and week 2 (p = p = 0.031), whereas, no statistical difference existed within control period of week 0 and week 2 (p = 1.00).

Table 4. Blood oxidative stress, lipid profiles, and IL-23 of all 30 healthy men.

	Reference range	Control period		After 4 weeks consumption
		Week 0	Week 2	
Oxidative stress status				
TAC (mmolTrolox/L)	-	1.04 ±0.17 (0.65-1.27)	1.01 ± 0.13 (0.72-1.18)	1.59 ± 0.11# (0.98-1.98)
GSH (mg/g Hb)	-	32.84 ± 11.71 (15.89-68.32)	34.82 ± 13.96 (16.32-72.11)	43.62 ± 14.83 # (22.28-77.08)
MDA (μmol/L)	-	3.32 ± 0.30 (1.48 -4.12)	3.11 ± 0.16 (1.51-3.35)	2.11 ± 0.34 # (0.75-2.32)
Lipid profiles				
Triglyceride (mg/dL)	35-160	120 ± 10.5 (58-250)	110.4 ± 55.6 (43-291)	90.67 ± 40.73 # (37-202)
Cholesterol (mg/dL)	<200	192.8 ± 38.2 (116-286)	189.1 ± 41.9 (114-325)	172.07 ± 34.48 # (110-263)
HDL (mg/dL)	Male (35-55 y)	54.5 ± 12.2 (38-89)	56.3 ± 12.7 (40-92)	54.53 ± 8.92 (35-76)
Pro-inflammatory cytokine IL-23				
IL-23 (pg/mL)	-	45.25 ± 11.31 (23.34-76.14)	44.01 ± 10.05 (22.09-71.45)	39.19 ± 11.25* (21.56-65.23)

Values are mean ± SD; range for each parameter is indicated below in parentheses. TAC = total antioxidant capacity, GSH = glutathione, MDA = malondialdehyde, HDL = high density lipoprotein, IL = interleukin. * p< 0.05 and # p < 0.01 compared to both week 0 and 2 in the control period. Data was statistical analyzed with a repeated measurement ANOVA and the Least Significant Difference (LSD) test.

Nutrient Composition in Ripe Banana Pulp

Moreover, results of nutrient composition analysis in one hundred grams of fresh banana presented humidity (61.5%), carbohydrate (27 g), total protein (1.5 g), total lipid (0.45 g), and ash (0.67%). The average weight of one banana pulp was 102.5 ± 3.4 g. Total phenolic content was 0.77 ± 0.03 mg of gallic acid equivalent to 1 g of fresh

weight. In addition, retinol acetate (vitamin A) was 37.5 ± 2.5 μg in 100 g fresh weight. However, in this study, L-ascorbic acid and alpha-tocopherol (vitamin E) could not be detected in the bananas.

DISCUSSION

This preliminary study was performed on healthy, non-athletic men with the normal BMI range and all laboratory tests. The design of the protocol had two periods of control and banana consumption for self-controlled subjects. The two-week control period was possibly adequate for showing the consistent condition of all volunteers. Furthermore, the food intake for all volunteers was recorded every day via a telephone call in order to control the behavior. In the results of physical strength assessment, only back-leg strength was shown; and three (exercise time, VT, RER) of four parameters in metabolic responses were changed statistically.

From the changed results of exercise time, VT, and RER, this can be possibly explained that the RER is roughly equivalent to the term of ventilatory threshold (VT), which is the ratio between O_2 and CO_2 [20] and a previous study reported that 0.75 ± 0.06 of RER corresponded to a substrate of 14.7% for CHO, whereas 0.89±0.02 corresponded to the substrate of 64.2% for CHO. In addition, that the RER also correlates to the result of significant longer AT time which indicates prolonged anaerobic glycolysis process [20], and also possibly relates to the longer exercise time on treadmill. Moreover, the reason is possible consistency with the high CHO consumption of banana that was shown in the nutrient analysis in this study. But the non-significant change of VO_2 is a possible limitation under submaximal intensity (80% MHR) [21], thus, the VO_2 level at this intensity in either consuming or non-consuming may show no statistical difference. In terms of physical strength, significant increase shown in only the back-leg strength is still unclear. When comparing the muscle work between all tests, both back and leg muscles possibly need more energy than the single hand or quadriceps muscle work. The relationship between high carbohydrate intake and glycogen storage with a muscle power has not been reported and confirmed, thus significant increase in back-leg strength in this study was still unclear and needs to be studied more in the future.

The results of the study found the content of total phenolic and retinoic acid (vitamin A) *in vitro*, and its results consistently showed a significant reduction of MDA in plasma and increase in GSH and TAC levels in subject blood after banana consumption. This result is similar to the previous data that presented the banana pulp as containing other antioxidant compounds such as catechin, epicatechin lignin and tannins, as well as anthocyanins [22]. Moreover, a previous evidence showed that aqueous extract from awak pulp has the highest total phenolic content (0.36± 0.01 mg of gallic acid equivalent/g fresh weight) [23]. Basic knowledge of antioxidant GSH and total phenolic compounds can scavenge H_2O_2 and $^{\bullet}OH$ and inhibit lipid peroxidation [24]. This study also investigated the effects of bananas on systemic inflammation markers, specifically, IL-23. Recently, the discovery of CD4+ Th17 T cells and the IL-23/IL-17 axis has challenged existing paradigms and the role of Th1 T cells in many autoimmune diseases [25]. Although, IL-23 not only synergize with IL-6 and IL-1 to promote IL-17 production [26], but it also plays a pivotal role in chronic inflammation related to the autoimmunity [27]. Although, this study shows a significant reduction in IL-23 level after 4 weeks of banana consumption that may be involved in the inflammation system, but the mechanism is still unclear. . Thus, other inflammatory markers as TNF-α, IL-6, or IL-17 makers should be more studied and confirmed. Even though, some previous evidence showed that the edible part of banana or juice can be used as tonic agent for gastro intestinal disorder like dyspepsia, constipation, or ascites [28], there is no evidence on the relationship between fruit, especially banana containing high CHO on inflammatory status that needs more studying in the future.

Finally, the results of nutrient composition analysis for human health, as well as in the previous evidence from USDA National Nutrient Database (2011) showed that the medium-sized bananas (approximately 118 g) contain 27 g of CHO, 3.1 g of dietary fiber, 105 kilocalories, potassium (422 mg), and vitamin B6 (0.43 mg) [29]. Closely similar to the findings of this study, 100 g of banana contained 61.5% humidity, 27 g of CHO, 1.5 g of total protein, 0.45 g of total lipid, and 0.67% of ash. Possibly results of low lipid and high CHO contents may affect the results of triglyceride and cholesterol after consumption. . In addition, the fruit supplementation has been promoted and is very challenging in sport competition due to a high amount of carbohydrate-loading capacity, high glycogen level in resting muscles,, delaying glycogen depletion and fatigue, leading to improvement in exercise endurance. For instance, a previous study showed that the acute effect of ingesting bananas on 75-km cycling performance increased on five metabolites related to liver GSH production, and eight biomarkers related to carbohydrate, lipid, and amino acid metabolism [30]. Therefore, banana has been suggested as a breakfast food (1x banana) and snack (1x banana) that contains a significant amount of carbohydrate. Moreover, carbohydrate intake of 5-7 g/kg body weight/day and 7-10 g/kg body weight/day is recommended for most regular exercises and periods of intense training, respectively [31]. Unfortunately, this

preliminary study was performed on small sample size (n=30) and on sedentary male subjects. Thus, it cannot be applied to another group as athletics or ill people. Therefore, the effects of banana supplementation involving the antioxidant, lipids, physical strength, and pro-inflammation condition, in the large number subjects, and in different people, especially in athletics also need more experiments.

CONCLUSION

Consumption of the pulp of 2 ripe bananas in the morning and evening for 4 weeks taking into account the back and leg strength and exercise time under the antioxidant condition, in addition possibly controls the triglyceride, cholesterol level, and pro-inflammatory IL-23 cytokine in healthy male subjects.

LIST OF ABBREVIATIONS

ABTS	=	2,2'-azino-bis 3-ethylbenzothiazoline-6-sulphonic acid
CBC	=	Complete Blood Count
DTNB	=	5,5'-dithiobis-(2-nitrobenzoic acid)
GSH	=	Glutathione
Hb	=	Hemoglobin
Hct	=	Hematocrit
HDL-C	=	High-density lipoprotein-Cholesterol
HPLC	=	High performance liquid chromatography;IL-23: Interleukin-23
LDL	=	Low-density lipoprotein
MDA	=	Malondialdehyde No
TAC	=	Total antioxidant capacity

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Human Ethics Committee Review Board following the Declaration of Helsinki in 1995 at the Faculty of Associated Medical Sciences, Chiang Mai University, Thailand and fifty healthy sedentary males.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

This study was supported by the research grant from the Thailand Research Fund (TRF) (Functional Food) (RGD 5420025). JL was responsible for obtaining funding, designing the study, establishing all protocol, performing laboratory testing, and performing data analysis. WE, JK, and AP gave critical comments and assisted to recheck the final manuscript version. All authors read and approved the final version.

REFRENCES

[1] Rastrelli L, Veneziano A, Aran S, De Simone F. Determination of carbendazim, thiabendazole and thiophanate-methyl in banana (*Musa acuminate*) samples imported to Italy. Food Chem 2004; 87: 383-6.
[http://dx.doi.org/10.1016/j.foodchem.2003.12.009]

[2] Saura-Calixto F, Goni I. Antioxidant capacity of the Spanish Mediterranean diet. Food Chem 2006; 94: 442-7.
[http://dx.doi.org/10.1016/j.foodchem.2004.11.033]

[3] Skidmore T, Smith P. Modern Latin America. 5th ed. New York: Oxford University Press 2001; pp. 148-9.

[4] Phuaklee P, Ruangnoo S, Itharat A. Anti-inflammatory and antioxidant activities of extracts from Musa sapientum peel. J Med Assoc Thai 2012; 95(Suppl. 1): S142-6.
[PMID: 23964457]

[5] Dikshit P, Shukla K, Tyagi MK, Garg P, Gambhir JK, Shukla R. Antidiabetic and antihyperlipidemic effects of the stem of *Musa sapientum* Linn. in streptozotocin-induced diabetic rats. J Diabetes 2012; 4(4): 378-85.

[http://dx.doi.org/10.1111/j.1753-0407.2012.00198.x] [PMID: 22429814]

[6] Kumar KP, Bhowmilk D, Nuraivel S, Umadevi M. Traditional and medicinal uses of banana. J Pharmacogn Phytochem 2012; 1: 51-63.

[7] Muchimapura S, Wattanathorn J, Thukhammee W. *Musa sapientum* extract decreases fatigue and oxidative stress markers in rats. Pharmacol Nutr 2014; 2: 102.

[8] López-Varela S, González-Gross M, Marcos A. Functional foods and the immune system: a review. Eur J Clin Nutr 2002; 56(Suppl. 3): S29-33.
[http://dx.doi.org/10.1038/sj.ejcn.1601481] [PMID: 12142958]

[9] World Health Organization (WHO). Diet, nutrition, and the prevention of chronic diseases. 1990.

[10] Dwyer GB. Muscular fitness: Muscular strength, muscular endurance, and flexibility. In: ACSM's health-related physical fitness assessment manual. 2nd ed. Tokyo: Lippincott Williams &Wilkins 2008; pp. 64-55.

[11] Kelln BM, McKeon PO, Gontkof LM, Hertel J. Hand-held dynamometry: reliability of lower extremity muscle testing in healthy, physically active,young adults. J Sport Rehabil 2008; 17(2): 160-70.
[http://dx.doi.org/10.1123/jsr.17.2.160] [PMID: 18515915]

[12] American College of Sport Medicine (ACSM). ACSM's guidelines for exercise testing and prescription. Philadelphia, PA: Lippincott Williams &Wilkins 2004; pp. 110-2.

[13] Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, Rice-Evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radic Biol Med 1999; 26(9-10): 1231-7.
[http://dx.doi.org/10.1016/S0891-5849(98)00315-3] [PMID: 10381194]

[14] Leelarungrayub D, Ketsuwan N, Pothongsunun P, Klaphajone J, Boomer RJ. Effects of N-acetylcysteine on oxidative stress, interleukin-2, and running time in sedentary men. Gazz Med Ital 2011; 170: 239-50.

[15] Human IL-23 Immunoassay. Mineapolis, MN: R&D systems, Inc. 2012.

[16] Leelarungrayub J, Laskin JJ, Bloomer RJ, Pinkaew D. Consumption of star fruit juice on pro-inflammatory markers and walking distance in the community dwelling elderly. Arch Gerontol Geriatr 2016; 64: 6-12.
[http://dx.doi.org/10.1016/j.archger.2015.12.001] [PMID: 26952371]

[17] Furusawa N. Rapid high-performance liquid chromatographic identification/ quantification of total vitamin C in fruit drinks. Food Control 2001; 12: 27-9.
[http://dx.doi.org/10.1016/S0956-7135(00)00021-9]

[18] Talwar D, Ha TK, Cooney J, Brownlee C, O'Reilly DS. A routine method for the simultaneous measurement of retinol, alpha-tocopherol and five carotenoids in human plasma by reverse phase HPLC. Clin Chim Acta 1998; 270(2): 85-100.
[http://dx.doi.org/10.1016/S0009-8981(97)00224-6] [PMID: 9544447]

[19] Zheng W, Wang SY. Antioxidant activity and phenolic compounds in selected herbs. J Agric Food Chem 2001; 49(11): 5165-70.
[http://dx.doi.org/10.1021/jf010697n] [PMID: 11714298]

[20] Brown SP, Miller WC, Eason JM. Exercise Physiology. Lippincott Williams & Wilkins 2006; pp. 114-5.

[21] Toda K, Oshida Y, Tokudome M, Manzai T, Sato Y. Effects of moderate exercise on metabolic responses and respiratory exchange ratio (RER). Nagoya J Med Sci 2002; 65(3-4): 109-13.
[PMID: 12580537]

[22] Someya S, Yoshiki Y, Okubo K. Antioxidant compounds from bananas (*Musa Cavendish*). Food Chem 2002; 79: 351-4.
[http://dx.doi.org/10.1016/S0308-8146(02)00186-3]

[23] Sulaiman SF, Yusoff NA, Elden IM, Seow EM, Supriaton AA, Ooi KL. Correlation between total phenolic and mineral contents with antioxidant activity of eight Malaysian bananas (Musa sp.). J Food Compos Anal 2001; 24: 1-10.
[http://dx.doi.org/10.1016/j.jfca.2010.04.005]

[24] Dröge W. Free radicals in the physiological control of cell function. Physiol Rev 2002; 82(1): 47-95.
[http://dx.doi.org/10.1152/physrev.00018.2001] [PMID: 11773609]

[25] Miossec P, Korn T, Kuchroo VK. Interleukin-17 and type 17 helper T cells. N Engl J Med 2009; 361(9): 888-98.
[http://dx.doi.org/10.1056/NEJMra0707449] [PMID: 19710487]

[26] Kastelein RA, Hunter CA, Cua DJ. Discovery and biology of IL-23 and IL-27: related but functionally distinct regulators of inflammation. Annu Rev Immunol 2007; 25: 221-42.
[http://dx.doi.org/10.1146/annurev.immunol.22.012703.104758] [PMID: 17291186]

[27] Duvallet E, Semerano L, Assier E, Falgarone G, Boissier MC. Interleukin-23: a key cytokine in inflammatory diseases. Ann Med 2011; 43(7): 503-11.
[http://dx.doi.org/10.3109/07853890.2011.577093] [PMID: 21585245]

[28] Panda H. Herbs cultivation and medicinal uses. New Delhi, India: National Institute of Industrial Research 2002; pp. 168-9.

[29] USDA Nutrient Database for standard reference. U.S. Department of Agriculture Research Service. Release 24, USDA website. Available: [http://www.nal.usda.gov/fnic/foodcomp/] Accessed Dec 15, 2011

[30] Nieman DC, Gillitt ND, Henson DA, *et al.* Bananas as an energy source during exercise: a metabolomics approach. PLoS One 2012; 7(5): e37479.
[http://dx.doi.org/10.1371/journal.pone.0037479] [PMID: 22616015]

[31] Bean A. Energy for exercise. In: The complete guide to sports nutrition. 7th ed.. 2013; 50.(1) London: Bloomsbury publishing Plc. 2013; pp.50-1.