Product Development of Rice Energy Gel and Effect on Blood Glucose and Lactate Concentration in General Sport Subject

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***Abstract*—Endurance sport training using long exercise time caused athlete to use blood glucose and glycogen resulting in fatigue in hour after session. Although athletes were encouraged to take electrolyte drinks (liquid form) before and during exercise session, these products generally require high volume to be effective. Athlete may carried more weight with them when exercising. The aim of this study was to develop rice energy gel from Thai Hommali Rice containing maximum oligosaccharides, vitamin B, and vitamin C for this purpose. Rice flour (Khao Dawk Mali 105 variety) was prepared and digested using α-amylase according to central composite design, varying in concentration of α-amylase (30, 50, 80AAU/ml), temperature (35, 45, 55˚C), and time (60,100,140 min). Optimized formula was used to produce energy rice gel and tested on 10 volunteer participants with the L.I.S.T protocol. Participants consumed rice energy gel (REG) or placebo (PLA). Results showed that the maximum mean blood glucose level of the REG ingestion group significantly (P<0.05) increased during training (127 mmol/L). Furthermore significantly different (P<0.05) compared to those of the PLA group (96.8 mmol/L) and maintained throughout the 75 min throughout the L.I.S.T training (111-126 mmol/L). Similar trend was found with blood lactate concentration at the beginning of training session but the effect was not retained after 30 min. However PLA group has significantly different (P<0.05) between after the last block when compare with the resting. Therefore, consumption of energy rice gel could be an alternative option for athletes who want to exercise longer without fatigue.**

***Index Terms*—rice, rnergy gel, sport nutrition, blood glucose, blood lactate**

I. Introduction

Consumers today has paid more attention to health and wellbeing compared to the past decades. Food and exercise were the main factors of one's health. However, a long exercise session caused the level of blood glucose to decrease. Once it completely drained, the body will take out muscle glucose causing the athlete to feel fatigue after exercise session. [1] Electrolyte drinks were developed to replenish this glucose loss. However, they require a consumption on average of 250-450 mL, which was not practical for many athletes.

Thai Hommali Rice (*Oryza sativa L.)* is Thailand local agricultural commodity. It contains 98% amylose and various minerals and vitamins, including thiamine (0.17-0.26 μg/100 g), niacin (5.16-10.3 μg/ 100 g) [1]. According to report from Department of Rice (2009) [2], Thailand produced Thai Hommali rice approximately 19 million ton/year. This rice was a good source of high quality carbohydrate providing high starch ratio. Its colour was pure white and has mild odour. Moreover, it contained various minerals and vitamins, which were essential to improve performance of athlete. Therefore, Hommali rice was a versatile raw material to produce/formulate functional foods [1].

α-Amylase widely used to hydrolysis for liquefied in fermented and beverage industry. When α-amylase hydrolyzed starch molecule transform polysaccharide to maltose which is Oligosaccharides.in addition Oligosaccharides is carbohydrates (carbohydrate) containing monomer for 3-10 molecules (monosaccharide) connected by glycosidicbond. These reaction produce combine of oligosaccharide dissolve into the solution [3], [4].

Generally, sports athlete and person who had regular exercise must receive nutrient such as electrolyte for substituted during training. Additionally, electrolyte ingestion can prolong exercise time. More evidence reveals that vitamin B can improve sports performance and raising metabolism constantly [2].

Nowadays, there are so many electrolyte drinks that produced for energized before or during exercise. Mainly component which is energy resource is carbohydrate. Average containing is 250-450 mL which not convenient to carry on because of their weight. Recent year carbohydrate gel is one of the choices which people select to use energized them while exercising. Size of carbohydrate gel container average between 40-150 m.

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So that is the reason why carbohydrate gel could be a better choice to use for drinking while exercising or matching. Some study show benefit when participants ingested carbohydrate gel compares with placebo or water that carbohydrate gel can improve sports performance or prolong exercise time [5]-[7]. However, carbohydrate has no difference in term of exogenous and total carbohydrate oxidation compared with carbohydrate drink ingested to each participants group during the exercise period [7]. Additional carbohydrate-electrolyte el ingestion raised blood glucose concentration and improve dribbling perfomance during the extra time period of simulate soccer match-play [8].

This study aims to use Thai Hommali Khao Dawk Mali 105 Rice to develope rice energy gel from the Thai Hommali Khao Dawk Mali 105 Rice and ingested to volunteer participants for confirming efficiency represents in term of blood glucose and lactate concentration to be evidence for claim benefit of this product.

II. Materials and Methods

A. Materials

Hommali var. Khao Dawk Mali 105 (*Hommali 105*) rice starch was purchased from B Natural Co., Ltd, Chiang Mai, Thailand. E-liquezyme, containing α-amylase 15,000 AAU/g, was obtained from Siam Victory Chemical co., Ltd, Bangkok, Thailand. Food additives (flavor and colour) and Carboxy Methyl Cellulose (CMC) were purchased from Yok intertrade co., Ltd. Other ingredients (citric acid, vitamin B complex, and vitamin C) were food grade and purchased from Union Science Co., Ltd, Chiang Mai, Thailand.

B. Preparation of Rice Starch for Digestion

Hommali 105 Rice starch was sifted through stainless steel sifter, Sieve No. 100 mesh (U.S. Standard Sieve Series, Dual Manufacturing Co., Chicago, LL, USA). After sieving, rice flour was mixed with distilled water at ratio of 1:3. The slurry was heated to 94.9 ± 0.1˚C for 5 min. At this temperature, the swelled rice flour reached a peak viscosity (3806 ± 164.3 cp) of pasting properties. Then, the slurry was allowed to cool down before adding enzyme in the next step.

C. Optimization of the Enzymatic Hydrolysis by Using α-amylase on Rice Starch

Central composite design (CCD) was used to plan the experiment, varying concentration of α-amylase (30, 50, 80 unit/ml), temperature (35, 45, 55˚C), and time (60, 100, 140 min). Three levels of the factor in CCD were coded -1, 0, and 1 (details as in Table I). Digested rice starch samples were analyzed for dextrose equivalent (DE) and total sugar (TTS). The results were used as criteria for optimization on response surface methodology in order to predict the best condition for preparing Rice Energy Gel.

TABLE I. Central Composite Design for Use to Determine Enzymatic Hydrolysis Response

Run	Enzyme Conc.(unit/ml)	T (˚C)	t (m)
1	-1	-1	-1
2	-1	-1	1
3	0	-1	0
4	1	-1	-1
5	1	-1	1
6	-1	0	0
7	0	0	-1
8	0	0	0
9	0	0	0
10	0	0	0
11	0	0	1
12	1	0	0
13	-1	-1	-1
14	-1	-1	1
15	0	-1	0
16	1	-1	-1
17	1	-1	1

D. Rice Energy Gel Preparation

Hommali 105 Rice starch was added distilled water by rice starch: distilled water; 1:3 then heat until rice starch gelatinized after that added enzyme α-amylase into the slurry and incubated in Bioreactor (New Brunswick sciencetific, Edison, New Jersey, USA) set temperature and incubated until an appropriate time. The concentration of enzyme, temperature which incubated and time to incubate used which specified the result after optimization. Then inhibited enzyme reaction by raising the temperature of the slurry reached 95˚c for 5 minutes. After that separated slurry the solid from a fluid. Only fluid was collected for mixing with others ingredients including Citric acid, Vitamin B complex, Ascorbic acid, and Carboxyl Methyl Cellulose. Finally, boil at 95˚C for 5 min, and hot filled in the container and cooled immediately.

E. Determination of Physical Properties

Five grams of slurry sample were measured viscosity using Brookfield instrument (DV-II+Pro, USA), probe number 18, 1 rpm at 25 ˚C. The colour of the slurry was measured by using Color Quest XE (Hunter Lab, city, country) in term of CIE L*a* b*.

F. Determination of Chemical Properties

pH: was measured by using pH meter (Cyber: Model scan-510 Singapore) followed AOAC (2000) [9].

Total acidity (TA) was determined with the titration method with 0.1 NaOH with using 5% phenolphthalein solution as indicator followed AOAC (2000) [9].

G. Determination of TTS (Total Sugar) and DE (Dextrose Equivalent)

Total sugar was measured by the phenol-sulfuric reaction method [10].

Reducing Sugar was measured by DNS-method [11].

DE (dextrose equivalent) adapted from Lane and Eynon (2010) [12] was calculated by the following equation:

$$DE\ value = \frac{Reducing\ Sugar(g)*100}{Total\ Sugar(g)} \quad (1)$$

H. Determination of the Nutrition Facts

Total energy (kcal), Energy from fat (kcal), Total Carbohydrate, Total fat, Fiber, sugar, Protein (calculated from % N*6.25) were measured follow In-house method

AOAC (2000) [9]. Sodium and Potassium Vitamin B2 Vitamin B12, Vitamin B3, Vitamin B6, Vitamin B5 and Moisture was measured followed AOAC (2000) [9].

I. Participants

Participants ten trained male soccer players were studying at the Faculty of Physical Education Srinakarintarawirot University (Age 20±1 years, Body mass 66.27±7.27 kg, Height 1.74±0.06 m, BMI 21.8±2.3, Blood pressure; systolic/diastolic : 126±10.1/69±7 mmHg, Pulse 74±12 bpm, %fat 14.3±1.7, Vo_{2max} 52.3±1.6 ml*kg^{-1} ; mean±SD) volunteer to participate in this research, which was approve by Faculty of Medicine, Chiang Mai university's ethics committee (Study code NONE-2561-05258). Before the commence-ment of this study, all participants were understood with all possible risks and discomforts fully explained to them in verbal and written form

J. The L.I.S.T Protocol

Day 1 at 5 pm. When participant came in to laboratory, they had to warmed body for 10 min. Then they undertook on cycle ergometer (Monark 824E, Vanbro, Sweden). After that, they cycled on 70% of VO_{2max} for 30 min until reached at the fastest speed by increasing the load to 2 times for 50 second and separated by 2 min rest. The overall would be 3 rounds. Finally, the volunteers continuously cycled on 70% of VO_{2max} for 45 min. At 8 pm on the same day, after exercise, all of the participants had a low-carbohydrate meal including cooked chicken breast with cooked rice and the total energy is 56 kJ/kg body mass. It approximately was 1-gram carbohydrate per 1 kilogram body mass. After pre-meal participants must not to eat or drink any food except water was allowed. The method was adapted from Patterson S., (2007) [13].

Day 2 at 8 am after participants report to the laboratory. At 8.30 am. participants had either REG or PLA 0.89 mL/kg body mass [BM] and also consumed water 5 mL/kg body mass [BM]. Afer the meal, volunteers went for training separately for 15 minutes with rest for 3 minutes for one block until reached totally five blocks. On resting period, participants ingested either REG or PLA 0.35 mL/kg BM and water 2 mL/kg BM. Besides, water ingestion attempted to offset any effect of dehydration. Each Block has a training pattern which was 3x20 m walking then speed run for 1x20 m at max speed reaching and then rest for 4 seconds. After that, the volunteers had a speed running 3x20 m at 55% of $VO_{2max.}$ and continued with 3x20 m speed running at 95% VO_{2max}. The method was adapted from Patterson S., (2007) [13].

After the training day, they must resting for seven days. The sequence of the intake of each participant random by use Latin square method.

K. Sampling Bloods

Fingertip capillary blood sampling one μL were taken for detect blood lactate concentration using Lactate Pro (Arkray, Inc., Kyoto, Japan) and blood glucose using One Touch Ultra analyzer (Johnson & Johnson Inc., California). Blood sampling was collected before and after training in each block. at before training, after training in each Block. a The method was adapted from from Patterson S., (2007) [13]

L. Statistical Analysis

All analysis was done in triplicate. Results were reported as mean ± s.d. The results were subjected to Statistical Analysis of Variane (ANOVA), using a Statistical Analysis Software (SAS, 2002). The significant difference between means was determined by Duncan's Multiple Rang Test (DMRT), where $p<0.05$ was considered for significant difference.

III. Results and Discussions

A. Optimization of Enzymatic Hydrolysis of Rice Starch

The result of optimization with response surface methodology (RSM) 3 factors CCD central composite design. Three-factor were the concentration of enzyme solution, incubation Temp and incubation time. There was a response which not different significantly is colour value and pH. But %tts and DE value had significantly different ($P<0.05$) were shown on the Table II. Criteria for optimized the predicted condition were the response with maximum %tts and minimum DE value but not higher than DE of maltodextrin. [14] (.The regression equation for maximum %tts and minimum DE value was DE = -40.6568102-1.255247164*conc + 3.466256309*Temp - 0.192563476*time + 0.010623513*conc^2 - 0.04368838* Temp^2 + 0.000164789*time^2 + 0.004452083*conc*Temp + 0.003463021*conc*time + 0.003923437*Temp*time with coefficients of determination (R^2) 0.96. Enzyme concentration was 20 AAU/mL solution, Temp: 54.48 °C and incubate time is 64.46 minutes were the optimized point to use for incubation shown on the Table III.

TABLE II. Show %Total Sugar and DE (Dextrose Equivalent)

Run	Enzyme Conc. (AAU/ml)	T (°C)	t (m)	% tts	DE
1	20	35	60	25.76±0.13^{f}	9.03±0.13^{n}
2	20	35	140	18.58±0.06^{k}	18.16±0.06^{g}
3	50	35	100	19.99±0.03^{k}	12.38±0.03^{l}
4	80	35	60	21.47±0.05^{j}	22.53±0.05^{e}
5	80	35	140	29.36±0.07^{b}	38.06±0.07^{c}
6	20	45	100	33.42±0.01^{a}	13.46±0.01^{k}
7	50	45	60	20.17±0.40^{k}	11.40±0.40^{m}
8	50	45	100	28.57±0.13^{c}	17.46±0.13^{h}
9	50	45	100	26.79±0.18^{de}	17.93±0.18^{gh}
10	50	45	100	19.60±0.21^{k}	17.98±0.21^{gh}
11	50	45	140	27.39±0.93^{d}	25.56±0.93^{d}
12	80	45	100	25.79±0.21^{f}	42.10±0.22^{b}
13	20	55	60	19.56±0.20^{k}	11.33±0.19^{m}
14	20	55	140	24.42±0.49^{i}	16.52±0.50^{i}
15	50	55	100	21.69±0.23^{j}	15.31±0.23^{j}
16	80	55	60	26.45±0.19^{e}	19.95±0.18^{f}
17	80	55	140	19.91±0.00^{k}	51.98±0.01^{a}

$^{a-n}$ mean in the same column with different superscript significantly different for Each Run ($p<0.05$)

TABLE III. SHOW OPTIMIZE CONDITION WERE SUITABLE FOR USE PRODUCED RICE OLIGOSACCHARIDE

Enzyme Conc. (AAU/mL)	T (°C)	t(m)	%tts	DE
20	54.48	64.46	24.35	9.03

The previous research study on structure and properties of starch. When Native starch gelatinized by the heating enzyme can digest the gelatinized starch easier than native starch [4], [14]-[19]. When native starch was swelling, and gelatinized starch granule size of granule will be cracked then the surface of granule increasing and enzymatic digestion will occur faster. [20]

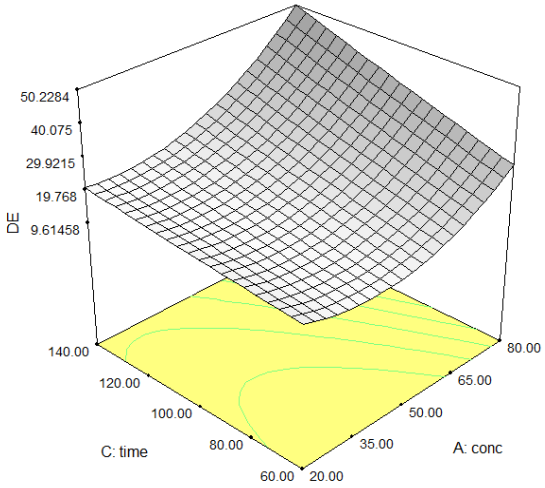

Figure 1. Response surface for DE (dextrose equivalent) of optimized digest rice flour condition

Hilary et al. studied producing maltose syrup by using α-amylase enzyme on tapioca starch found that pH and Temp60-65°C were suitable for produced 79% maltose syrup [14]. According to Yutthachai (2014) was used 0.04 % α-amylase concentration (v/w) pH 6.5 at 90 °C 10 minutes for produced maltose syrup DE=12. Lin Q. *et al*. was studied condition were used for produced isomalto-oligosaccharide syrup found that can provide a syrup with DE=12-18, 59.20 %yield with use α-amylase for hydrolyzed. Also, Chockchaisawasdee and Naiyatat (2013) were studied produced isomalto-oligosaccharide syrup by used α-amylase on banana starch [18]. (Fig. 1)

B. Nutrition Fact of Rice Energy Gel

Table IV shown various minerals and vitamins which the final rice energy gel contained, which were essential to improve performance of athlete. Williams and Melvin H (1989) reported that food containing vitamin B 40 mg could enhance the performance of marathon men over 40% [1]. Therefore, Hommali rice was a versatile raw material to produce/formulate functional foods [21]. The Blood glucose concentration at rest did not make significant ($P<0.05$) when compared between trial (PLA: REG; 95.9±4.9 mmol/L, 97.3±6.4 mmol/L respectively). Frequently blood glucose concentration after training on Part A before the L.I.S.T was not significantly ($P<0.05$) different and still on the average level of the glucose concentration of healthy person [7], [8], [22].

TABLE IV. SHOW THE NUTRITION FACTS AND COMPONENT OF RICE ENERGY GEL THAT WAS USED IN THIS STUDY

Nutrition Component	Amount
Total energy (kcal)	108.62
Energy from fat (kcal)	1.08
Carbohydrate (g)	26.64
Sugar (g)	4.3
Fat (g)	0.12
Protein (g)	0
Fibre (g)	0.06
Sodium (mg)	92.797
Potassium (mg)	7.02
Vitamin C (mg)	12.5
Vitamin B2 (μg)	0.36
Vitamin B12 (μg)	0.00181
Vitamin B3 (μg)	0.00141
Vitamin B6 (μg)	0.01075
Vitamin B5 (μg)	0.22972

PLA which is equally flavored, colored and electrolyte was added in the same amount.

C. Plasma Metabolite

Glucose level of PLA did not significant ($P<0.05$) since Resting through finished the L.I.S.T training (Rest: 95.9±4.9 mmol/L, Block 1: 95.6±5.8 mmol/L, Block 2: 96.8±4.7 mg/L, Block 3: 98.2±5.5 mg/dL, Block 4: 99.0±6.1 mmol/L, Block 5: 97.7±7.2 mmol/L respectively). These result can assume that PLA which is equally flavoured and colour have the efficiency to blind participants along experiment. Due to the previous study, energy placebo gel cannot raise glucose blood concentration significantly ($P<0.05$) [6], [23]-[25]. On the other hand REG ingestion can increase glucose level and significantly different ($P<0.05$) since the first Block of the L.I.S.T training on the Table V. Due to previous research found that when participants consume carbohydrate fluid ingestion, then training for 15 min on each protocol blood glucose concentration raised significantly ($P<0.05$) and exogenous carbohydrate which intake was detect from breath [6], [7]. After Block 2 blood glucose concentration was the highest value (126.7±14.6 mmol/L). Although blood glucose concentration in Block 2 was the highest value no different significantly ($P>0.05$) when compared with the period of Block 1, Block 3 and Block four the result shown on the table 5. This result may be affected by a combination of the various type of carbohydrate that contains in the gel. Similarly in several pieces of research that study of the kind of carbohydrate that ingested by participants then the response in term of blood glucose concentration compared with placebo ingestion. Jentjense *et al*.(2005) and Roberts et al studied the effect of intake of only glucose or sucrose, and the combination of glucose and sucrose result reveals that the oxidation rate of high dose combination was higher than the single type of carbohydrate used. [7], [25] Furthermore, peak exogenous of sucrose ingestion and the mixture was higher than the group whose intake only glucose

significantly (P<0.05) [7]. A maximum of oxidation of glucose combination with sucrose was higher 21% than only glucose. Robert, Justin et al. (2014) studied with Maltodextrin and its combination with fructose they found that maltodextrin and combination have the efficiency to raise blood glucose and improve performance time of exercise [24]. From several research that when participants consume a mixture of oligosaccharide not only the glucose concentration in blood was increase significantly more than placebo, water or consume only glucose, but also improving performance, For instance ingestion sucrose which the one of oligosaccharide can retard RPE (Rate Perceived exertion) and RER (Respiratory exchange ratio) better than ingestion only glucose. RER and RPE related to producing hydrogen ion and lactic acid in bloodstream [26]

TABLE V. BLOOD GLUCOSE, BLOOD LACTATE AS RESTING AND AFTER EACH LIST BLOCK TRAINING

Variable		Resting	LIST Block Number				
			1	2	3	4	5
Glucose (mmol/L)	PLA	95.9±4.9^{a}	95.6±5.8^{a*}	96.8±4.7^{a*}	98.2±5.5^{a*}	99.0±6.1^{a*}	97.7±7.2^{a*}
	REG	97.3±6.4^{c}	120.2±12.9$^{ab*\,t}$	126.7±14.6$^{a*\,t}$	116.7±20.9$^{ab*\,t}$	116.1±16.0$^{ab\,t}$	111.4±14.0$^{b*\,t}$
Lactate (mmol/L)	PLA	1.4±0.5^{b}	2.9±1.8^{ab}	2.8±1.4^{ab}	2.5±1.4^{ab}	2.9±1.8^{ab}	3.6±2.8$^{a\,t}$
	REG	1.7±0.8^{b}	3.0±1.5^{ab}	3.±2.5$^{aA\,t}$	2.6±1.0^{ab}	2.6±0.8^{ab}	2.9±1.5^{ab}

Value are means ± SD; N = 10. Resting represents the resting stage and LIST Block Number 1-5
^{ABC} Significantly different variable in the same fluid ingestion (P < 0.05), * Significantly different compared between the trial in the same response (P < 0.05), ^{t} significantly different from resting stage

From Fig. 2 which shown the plot of blood glucose concentration the trend line of REG intake has to tend to decrease but blood glucose after Block 5 different significantly (P<0.05) from the highest value (Block 2). However blood glucose after Block 5 did not significantly different (P>0.05) from Block 1, Block 3 and Block 4 (120.2±12.9 mmol/L, 116.7±20.9 mmol/L, 116.1±16.0 mmol/L respectively).

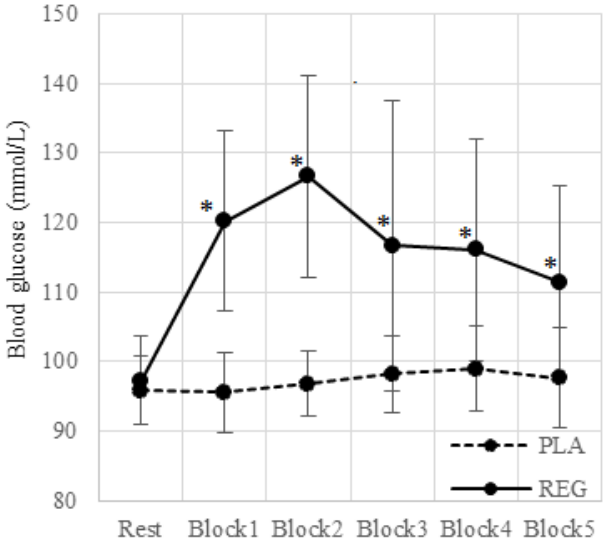

Figure 2. Blood glucose concentration in resting stage and after LIST each block training. Value are means ± SD; N = 20. *significantly different (P<0.05) from resting stage

Moreover, the REG ingestion group has higher blood glucose concentration than PLA group significantly (P<0.05) while perform the L.I.S.T training show in the Fig. 2. Moreover in the Fig. 3 show compared of blood glucose of PLA between REG ingestion at Rest and Block 5. The glucose concentration of REG ingestion on Block 5 higher than resting significantly (P<0.05) (Rest: 95.9±4.9 mmol/L vs. Block 5: 111.4±14.0 mmol/L respectively) and differ from PLA ingestion which did not significant (P<0.05) on Resting versus Block 5 (Rest: 95.9±4.9 mmol/L vs. Block 5: 97.7±7.2 mmol/L respectively). There is so many research that supports the benefit of carbohydrate intake not only in gel form but also including liquid form too.

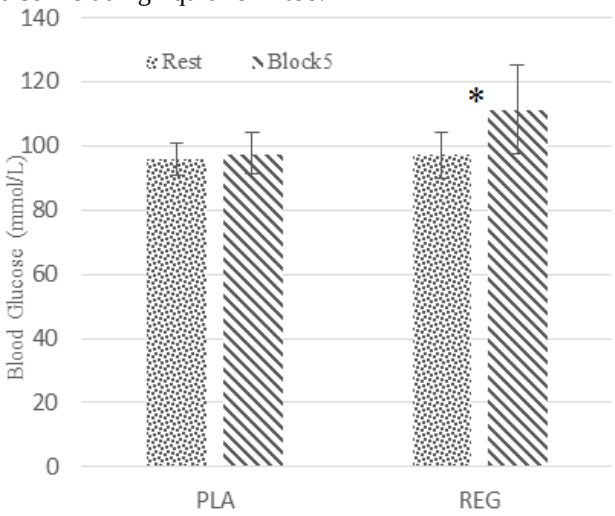

Figure 3. Compare blood glucose concentration of resting stage and block 5 in LIST training.Value are means ± SE; N = 20. ** significantly different from resting stage

Lactate concentration at rest did not make significant (P<0.05) when compared between trial (PLA: 1.4±0.5 mmol/L, REG: 1.7±0.8 mmol/L respectively). Blood lactate concentration of placebo among the L.I.S.T training did not significantly different (P<0.05) (Rest: 1.7±0.8 mmol/L, Block 1: 3.0±1.5 mmol/L Block 2: 3.±2.5 mmol/L, Block 3: 2.6±1.0 mmol/L, Block 4: 2.6±0.8 mmol/L, respectively). However, after Block 5 lactate concentration different from Resting stage significantly (P<0.05) (Rest: 1.7±0.8 mmol/L vs Block 5:

3.6±2.8 mmol/L respectively). Blood lactate concentration of REG ingestion from resting is not significant (P<0.05) since resting stage through finished the L.I.S.T training excepted lactate value on block two was the highest and different significantly (P<0.05) from the resting but not significant (P<0.05) among the L.I.S.T training. The result is shown in the Fig. 4 that the lactate concentration of REG ingestion can maintain lactate concentration.

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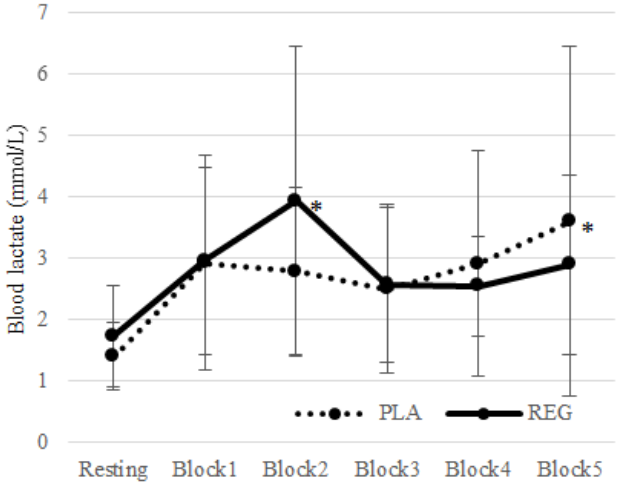

Figure 4. Blood lactate concentration in resting stage and after LIST each block training Value are means ± SD; N = 10. * significantly different from resting stage

On the other hand, the PLA ingestion cannot decrease lactate concentration in blood even if maintain blood lactate at the same level. In addition the lactate concentration of REG ingestion on Block 5 was the same level of resting significantly (P<0.05) (Rest: 1.7±0.8 mmol/L vs. Block 5: 2.9±1.5 mmol/L respectively) and differ from PLA ingestion which was different significantly (P<0.05) on Resting versus Block 5 (Rest: 1.4±0.5 mmol/L vs. Block 5: 3.6±2.8 mmol/L respectively) show in Fig. 5. Blood lactate related to the pH and acidity of the blood [22]. Lactate will increase hydrogen ion and reduction pH in the bloodstream which developed fatigue because when the participants are performing exercise or training [26]. Usually, the body uses oxygen to produce energy for use in sports performance we call this reaction is aerobic respiration, and when oxygen did not transport to cell sufficiency, the cell will turn to anaerobic metabolism and produce lactic acid, and these lactic acid turn to be lactate into the blood [26].

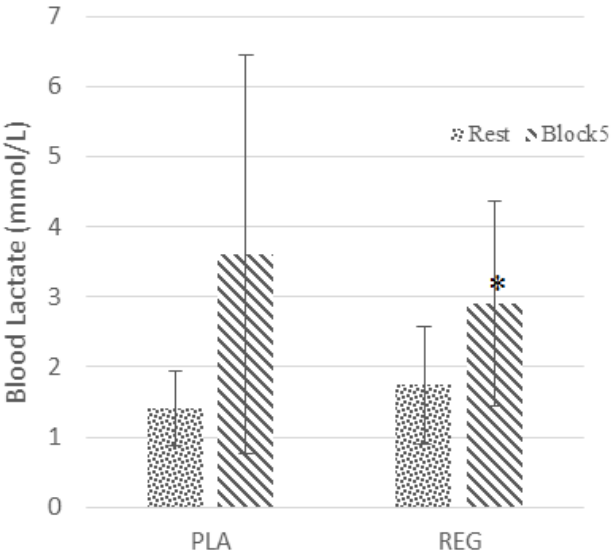

Figure 5. Compare blood lactate concentration of resting stage and block 5 in LIST training.Value are means ± SE; N = 20. ** significantly different from resting stage

Lactate concentration was raised to a high level, it will be effected to the Endurance performance, and this effect may not be suitable for an athlete who wants to prolong the time of their performance in the same way of glucose concentration in the bloodstream. When we perform exercise or long time exercises such as Marathon, Triathlon or more than 30-minute performing glucose in blood and glycogen in liver and muscle will be used to metabolized turn to energy when glucose in blood has decreasing, the performance was lower than the group that intake glucose for maintaining blood glucose level. Many research reveal the result of carbohydrate intake before and while training, group which receive carbohydrate either gel or fluid form have a higher performance [23], [24] such as mean sprint speed faster than the placebo group and improving sprint performance [23], enhance performance during extra-time period of simulated soccer match-play [23], [27], prolong intermittent exercise performance [6], [23] and improving cycling performance [28].

IV. Conclusion

Rice electrolyte gel contained not only glucose but also the combination of varies of oligosaccharide such as glucose, maltose and maltodextrin which is the criteria when optimised the enzymatic hydrolysis in Part A. from a result of REG ingestion on blood glucose can prove the hypothesis of this research is the REG ingestion can maintain blood glucose concentration through the training period and can control lactate concentration in the same level of resting stage in the bloodstream. We can assume

that Rice energy gel can maintain blood glucose and lactate concentration which may be a benefit for the endurance athlete to prolonged exercise or improved sports performance.

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