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Sport Drink Containing Maltodextrin to Improve Physical Performance of Soccer Athletes

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Abstract. Sport drinks consist of carbohydrates and electrolyte drinks. Carbohydrates needed for energy metabolism in Soccer athletes. Maltodextrin is one type of carbohydrate that is easily soluble in water and quickly absorbed by the intestines. Therefore, it is suitable for sport drink products. This research is a completely randomized design with 1 factor and three repetitions. There are two concentrations of maltodextrin in addition to 300 mL of electrolyte drinks, i.e., 6% (18 g) and 8% (24 g). Atomic Absorption Spectrophotometry (AAS) analysis is used to analyze minerals in sport drink products consisting of sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg). Descriptive organoleptic analysis was also used to assess the respondent's level of preference for the product. Sport drink products with the addition of 6% equal to 18 g maltodextrin in 300 mL electrolyte drink was more acceptable by respondents than 8% of maltodextrin because theoretically, it was closer to the osmolarity of the athlete's body. The composition of Na, K, Ca, and Mg in sports drinks that add 6% of maltodextrin was 0.63 ppm, 0.55 ppm, 0.72 ppm, and 0.0014 ppm, respectively. Those minerals composition is closer to the amount of fluid needed of Soccer athletes during exercise. Analysis of best treatment using De Garmo effectiveness index method also found that added 6% of maltodextrin is preferrable than 8% of maltodextrin. The addition of maltodextrin in electrolyte drinks might be an effective way to improve the physical performance of soccer athletes.

INTRODUCTION

Soccer is one of popular sport which is played by all of age group and gender. The duration of this sport is 90 minutes. During the time, soccer athletes do some numerous explosive activity such as running, kicking, jumping, tackling, etc. However, soccer performance not only supported by technical, tactical, and mental aspects, but also physiological aspect being an issue that have to be concerned [1]. Physiological aspect plays an important role on soccer athlete's performance, and energy metabolism being main indicator of this aspect. During exercise and competition, soccer athletes use anaerobic and aerobic energy metabolism, so that because of anaerobic energy metabolism could not existing for long period, aerobic energy metabolism being dominant used by soccer athletes [2]. Aerobic energy metabolism is used to support muscle contraction. The muscle contraction reflects human physically movement marked by the activity of binding between actin and myosin. Adenosine Tri Phosphate (ATP) used as main component to support those activities [3]. ATP also play an important role in energy metabolism source during endurance sport like soccer. The supply of ATP during exercise and competition in soccer athletes being fundamental, since aerobic energy metabolism running. Sources of nutrition compound which is used for aerobic metabolism are carbohydrate dan fat. Compared with fat, carbohydrate is more preferrable and being a primary source for energy metabolism [4].

Water balance and electrolyte also play an important role in endurance sport performance. The long duration of soccer exercise and competition cause sweat loss and reduce fluid body. Therefore, fluid provision is recommended

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in order to prevent dehydration. Based on some literatures, dehydration reduce performance and cognitive function of muscles [5]. Mineral and trace element (MTE) perform as electrolyte compound which is very needed to prevent muscle acidosis. Several MTE, which is possibility, lost gather with sweat loss are sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg). Because of those MTE also being a key role in order to prevent muscle acidosis, so that electrolyte compound is also very needed by soccer athletes [6]. One of study in Poland shown that providing some MTE in particular with sodium (Na), potassium(K), calcium (Ca), and magnesium (Mg) improves performance of elite soccer players. The improvement of performance was caused by the increased of resting blood pH, therefore it reduced fatigue and risk of acidosis of research subjects [7].

Considering the background, in order to prevent the depletion of ATP, fluid, and electrolyte supply during exercise and competition, soccer athletes need specific treatment. Providing sport drink contain carbohydrate and electrolyte significantly impact on some functional variables of performance of soccer players [8]. By the definition, sport drink is a drink with liquid substance where water is the main ingredient. The basic formulation of sport drink is related to body's osmolarity. Beside water, in order to keep ATP supply, the concentration of carbohydrate content must be well counted [9]. The concentration of carbohydrate which is addition in sports drink were not well documented so far. Some literature shown that the range of carbohydrate concentration were 6 – 8%. Each concentration performed the availability of physicochemical and level of acceptance by subjects [10]. Therefore, this study aims to analyze the best treatment of sport drinks with comparing the 6% and 8% concentration of carbohydrate content.

MATERIAL AND METHODS

This research is an experimental study in food and nutrition using the Complete Randomized Design with one factor, the concentration of maltodextrin (M). The concentration of maltodextrin addition consists of two levels, i.e., the addition of 6% w/w (M_1) and 8% w/w (M_2) maltodextrin. Each level of treatment is repeated three times so that there are six treatments.

Preparation of Sport Drink

The main ingredient used in the preparation of the sport drink is alkaline water with the brand "Cheers Alkaline," with a pH of more than 8.5 purchased directly from mineral water producers (PT Atlantic Biruraya). The maltodextrin used in this formulation has a DE (Dextrose Equivalent) value of 10-12, yellowish-white color, not too sweet, and has 6% moisture. The composition of sport drinks with the addition of maltodextrin is presented in Table 1.

TABLE 1. The Composition of Sport Drink

Ingredients	Treatment (n=6)	
	M_1	M_2
Maltodextrin	18	24
Alkaline Mineral Water (mL)	300	300

Treatments: M_1= the addition of 6% w/w maltodextrin; M_2= the addition of 8% w/w maltodextrin
Replicated three times, so that the total is six treatments

The production of sport drinks is done by mixing maltodextrin with alkaline water as much as 300 mL. The mixture is then homogenized until the entire maltodextrin can dissolve in water.

Physicochemical Analysis of Sport Drink

Physicochemical analysis conducted in the form of analysis of sports drink mineral levels include sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg). Mineral content analysis was conducted in the Department of Agricultural Products Technology laboratory, Faculty of Agricultural Technology, Brawijaya University, Malang, East Java, Indonesia, using the Atomic Absorption Spectrophotometry (AAS) method. The analysis of each mineral content is done with three times replication (triple).

Panelists of Sport Drink Sensory Analysis

The panelists in this study were young male athletes in Pusat Pendidikan dan Latihan Olahraga Pelajar (PPLOP), Semarang, Central Java, aged 15-18 years. The study subjects were 17 young male soccer athletes selected using total sampling.

Sensory Analysis of Sport Drink

Sensory analysis conducted in the form of descriptive organoleptic tests using hedonic quality acceptance test to know the level of preference of panelists to the product presented. The hedonic quality acceptance tests were conducted on the aroma, color, texture, and taste quality characteristics of the two formulations (M 1 and M2). All panelists presented the product simultaneously; then the panelists assessed the quality characteristics of aroma, color, texture and taste using 5 points of quality scale (very like (scale 5), like (scale 4), neutral (scale 3), dislike (scale 2), and very dislike (scale 1). The scale is then transformed into a numerical scale of 1-5 that increases according to the degree of difference or preference [11].

Data Analysis

The data of the study results were analyzed using Statistical Package for Social Science (SPSS) 25.0 for Windows. All data is analyzed univariate (descriptive) and then analyzed bivariate. Physicochemical data of sport drink analyzed with the Mann-Whitney U nonparametric test by comparing the result of mineral content of both of treatment group (M1, M2). In line with physicochemical data, the sensory sport drink data was also analyzed with the Mann-Whitney U nonparametric test with a confidence level of 95% (α=0.05) to determine the differences in each treatment group. Data analysis then continued to determine the best treatment using the de Garmo effectiveness index [12, 13].

RESULT AND DISCUSSION

Analysis of physicochemical properties was conducted to determine the levels of mineral sport drinks added maltodextrin with different concentrations (6% and 8%). Based on the results of the analysis, it is known that there is no difference in the mineral levels of sodium, potassium, calcium, and magnesium content between sport drinks added 6% maltodextrin and added 8% maltodextrin. This result is indicated by a value of $p > 0.05$ (Table 2).

TABLE 2. The Characteristics of Sport Drink

Characteristics	Mean ± SD (N=6)		P-value
	M_1	M_2	
Mineral Contents (ppm)			
Sodium	0.63 ± 0.013	0.87 ± 0.009	0.100
Potassium	0.56 ± 0.016	0.78 ± 0.017	0.100
Calcium	0.73 ± 0.008	1.06 ± 0.010	0.100
Magnesium	0.0014 ± 0.00020	0.0055 ± 0.00029	0.100
Sensory Quality			
Aroma	4.53 ± 0.717	4.53 ± 0.624	0.982
Taste	4.47 ± 0.874	3.71 ± 0.920	0.038*
Texture	4.47 ± 0.717	4.47 ± 0.800	0.892
Color	4.47 ± 0.874	4.29 ± 0.920	0.610

Treatments: M_1= the addition of 6% w/w maltodextrin; M_2= the addition of 8% w/w maltodextrin
Replicated three times, so that the total is six treatments
Analysis using Mann-Whitney U Test
Significant at 0.05 ($p<0.05$), significancy is showed with the notation *

Based on the result, it clearly mentioned that the addition of maltodextrin to mineral water as much as 6% and 8% w/w did not show a significant difference in mineral content. Even so, it appears that the addition of maltodextrin as much as 8% w/w always shows a higher mineral content than sports drinks added 6% w/w maltodextrin. The higher concentration of adding maltodextrin associated with the presence of metals in the hydroxyl group of maltodextrins. Therefore, the more concentration of maltodextrin added to a sports drink, the more the mineral content will increase. Some literatures state that the hydroxyl group of maltodextrin consists of metal derivatives. The metal derivatives are

the result of bonds between metals and oxygen atoms. This bond is stable against heating and hydrolysis processes [14]. It has been mentioned in the previous study that the concentration of carbohydrate which is adding to sport drink approximately between 6-8% and it depend on the kind of sport [15,16]. The regulation of isotonic drink quality requirement was well documented in Standar Nasional Indonesia (SNI) number: SNI 01-4452-1998 by Badan Standarisasi Nasional since 1998. The regulation state that the concentration of carbohydrate which is added in isotonic, or sport drink is 5% for the minimum and the sodium content is less than 800 mg/kg or equal as less than 1.06 ppm [17]. Compare with SNI, both of treatment show that the sodium content is less than 1.06 ppm, i.e., 0.63 ± 0.013 ppm for M1 and 0.87 ± 0.009 ppm for M2, respectively. So that these treatments (M1 and M2) are still suitable to SNI content.

TABLE 3. Panelist Assessment of Sport Drink Quality

Characteristics	Treatments			
	M_1		M_2	
	N	%	N	%
Aroma				
Neutral	2	5.9	1	2.9
Like	4	11.8	6	17.6
Very Like	11	32.4	10	29.4
Taste				
Neutral	10	29.4	4	11.8
Like	2	5.9	1	2.9
Very Like	5	14.7	12	35.3
Texture				
Neutral	2	5.9	3	8.8
Like	5	14.7	3	8.8
Very Like	10	29.4	11	32.4
Color				
Neutral	4	11.8	5	14.7
Like	1	2.9	2	5.9
Very Like	12	35.3	10	29.4

Treatments: M_1= the addition of 6% w/w maltodextrin; M_2= the addition of 8% w/w maltodextrin
Number of panelists=17
Sensory Test using Hedonic Quality Acceptance Test with Likert scale (1-5)

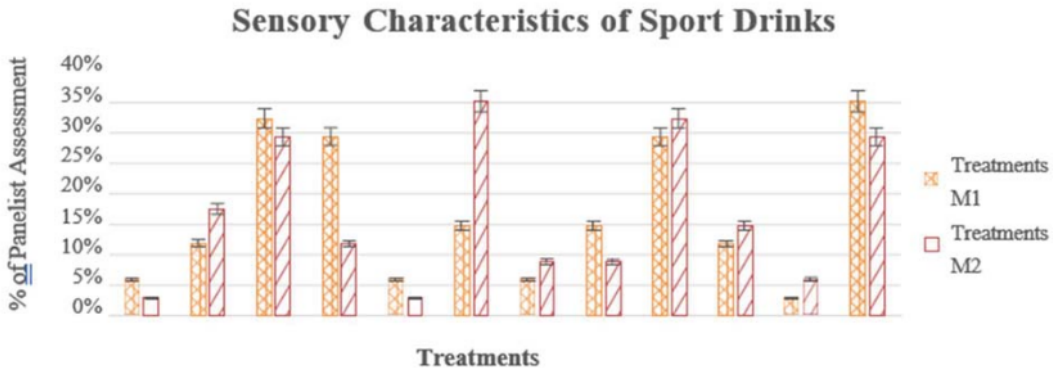

FIGURE 1. Panelist assessment of Sport Drink Quality. The values are representing of percent of subjects (n=17). Treatment: M1 = Addition of 6% maltodextrin, M2 = Addition of 8% maltodextrin

Table 3 show that based on the results of the assessment of 17 panelists, it is known that all panelists like all sport drinks, both added 6% and 8% maltodextrin. The values of sensory test using 5 scales, i.e., very dislike, dislike, neutral, like, and very like. However, almost all panelists gave scale 3 to 5 which is mean that both of treatment of sport drinks are acceptable by all panelists. It well mentioned before those parameters of sensory quality are aroma, taste, texture, and color. Based on the bivariate analysis using Mann-Whitney U nonparametric test, there is a significant different panelist assessment of the taste quality between the sport drink which added 6% maltodextrin and

the added 8% maltodextrin. This result is indicated by the value p=0.038 (p<0.05). Sensory quality of aroma, texture, and color did not indicate a significantly different panelist's assessment (Table 2). Based on figure 1, it shows that sport drink which is added 6% maltodextrin had 29.4% higher neutral scale than added 8% maltodextrin. Although very like scale is dominantly had in sport drink which is added 8% maltodextrin, but almost all panelists prefer that the sport drink had plain taste.

Sport drink is very necessarily needed for soccer athletes during exercise and competition. Therefore, determination of the best treatment between M1 (6% w/w maltodextrin) and M2 (8% w/w maltodextrin) is very needed. The sport drink product is not only acceptable by athletes regarding those physicochemical content, but also regarding the sensory test for measuring the level of acceptance of those products by athletes. De Garmo effectiveness index method used to determine the best treatment of sport drink within 6% w/w maltodextrin or 8% w/w maltodextrin by combining all parameters, i.e., sodium, potassium, calcium, magnesium, texture, color, taste, and aroma (Table 4).

TABLE 4. Determination of Effectiveness Index

Variable	BV	BN	M_1		M_2	
			NE	NH	NE	NH
Sodium	0.482587	0.092	1.000	0.092	0.000	0.000
Potassium	0.686567	0.131	0.000	0.000	1.000	0.131
Calcium	0.517413	0.099	0.000	0.000	1.000	0.099
Magnesium	0.467662	0.089	0.000	0.000	1.000	0.089
Texture	0.830846	0.158	1.000	0.158	0.000	0.000
Color	0.472637	0.090	1.000	0.090	0.000	0.000
Taste	0.78607	0.150	0.000	0.000	1.000	0.150
Aroma	1	0.191	1.000	0.191	0.000	0.000
Total	5.2	1.000		0.531*		0.469

Notes:
Determination of the best treatment using the de Garmo effectiveness index method based on the rank choices of panelists (n=17) to all parameters (sodium, potassium, calcium, magnesium, texture, color, taste, and aroma).
BV=Weight of Valence; BN=Relative Weight; NE=Effectiveness Value; NH=Result Value.
The best treatment is the highest score of NH; it is showed by notation *
Treatments: M_1= the addition of 6% w/w maltodextrin; M_2= the addition of 8% w/w maltodextrin

Based on the de Garmo effectiveness index method's results, the best treatment is M1 (6% w/w maltodextrin). The addition of 6% w/w maltodextrin on sport drink as the best treatment have lower mineral contents (sodium, potassium, calcium and magnesium) but have better sensory characteristics than sport drink with 8% w/w maltodextrin addition (Table 2). Panelists' assessment of the sensory quality of sports drinks showed that there was a significant difference in taste between sports drinks with 6% w/w maltodextrin added and 8% w/w maltodextrin added. The results also showed that the average panelist's assessment of the taste quality of sports drinks with 6% w/ w added maltodextrin was better than 8% w/w maltodextrin added (Table 2). This is associated with the panelists' perception of taste which is influenced by color sensory characteristics. The sports drink served to the panelists has a clear color and almost resembles ordinary mineral water. When consuming sports drinks with the addition of 6% w/ w maltodextrin, the panelists almost did not feel a sweet taste sensation, so the panelists assumed that what they consumed was ordinary mineral water. As for sports drinks, which added 8% w/w maltodextrin produced a sweeter taste that was more dominant, but with a clear drink color, the panelists had a taste perception that did not match the color of the drink. That's why the characteristic of added 6% w/w maltodextrin in sport drink with clear drink color and plain taste are preferable.

The minerals content of M1 (6% w/w maltodextrin) were lower than M2 (8% w/w maltodextrin), but it's still suitable to SNI content. Moreover, based on Recommended Dietary Allowance (RDA), the sodium requirement for adults is 1500 mg/day. Some research that examines the mineral composition and nutritional content of isotonic drinks or sport drinks, it shows that the intake of 250 cc of isotonic drinks can supply the sodium requirement of 14.8% of the RDA or about 222 mg. The recommendations for filling out the maximum needs for magnesium and sodium minerals in sport drinks are 19.4% and 19.8% or equivalent to 69.84 mg and 297 mg [18,19]. Many literatures showed that both of concentration of carbohydrate and mineral content have to suitable with body's osmolarity. The concentration of carbohydrates that is very suitable to be added in sport drinks is 6% because it equivalents of 280 mOsm/L osmolarity and isotonic to human body fluids (280-300 mOsm/L) [20]. Shirreffs et al [9] observed several sport drink brands, he also found that the optimum concentration of carbohydrate which have to added to sport drink was 6% (280 – 286 mOsm/L), because of its closest to body's osmolarity. Furthermore, giving sport drink which is

added 6% w/w carbohydrate to soccer athletes during exercise and competition is beneficial in helping to prevent deterioration in performance of athletes [21].

CONCLUSION

Sport drink contain carbohydrate and electrolyte drinks which is very needed for endurance athletes including soccer. The content of carbohydrate and minerals in sport drink have to suitable and closest to body's osmolarity, physicochemical and level of acceptance of athletes. By comparing both of treatment (M1 and M2), it clearly showed that by adding 6% w/w maltodextrin in sport drink is preferrable than 8% w/w maltodextrin. Some of previous study also showed that by adding 6% w/w carbohydrate in sport drink could improve athletes' performance and delay fatigue.

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