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Chemical compositions and sensory characteristics of sports drinks formulated from *Salacca sumatrana* (Becc.) fruit

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Abstract

Prolonged exercise causes excessive fluid loss through sweat which could cause fatigue and reduced performance. Athletes need to restore this fluid loss orally, either from water or carbohydrate-electrolyte drinks. Carbohydrate-electrolyte drinks could be formulated from fruits, such as salak, also known as snake fruit, for instance. This study aimed to develop a sports drink formulated from Sidimpuan salak (*Salacca sumatrana* (Becc.)) fruit. The formulation of Sidimpuan salak Sports Drink (SSSD) included salak fruit, water, salt and glucose syrup. Salak was blended with a slow juicer to obtain the extract, and mixed with water, salt, and glucose syrup. The SSSD formulation consisted of three formulas, SSSD1, SSSD2, and SSSD3 which differ in the amount of extract added, 250, 200, and 150 mL, respectively. Sensory analysis showed that the panellists enjoyed the sports drink formulation by giving an average rating of 3.4 for colour, 3.4 for aroma, 5.4 for taste and 5.4 for texture. The SSSD1 formulation which was most preferred by the panelists was found to have ash content of 0.33 g/100 mL, total fat of 0.31 g/100 mL, protein of 0.52 g/100 mL, carbohydrate of 13.88 g/100 mL, and total energy of 60.42 g/100 mL. The carbohydrate content and total calories of SDSS1 were significantly different from the other two formulations. From the results obtained, the SSSDs have potential to be developed as a more affordable sports drink, especially among locals.

1. Introduction

Athletes require adequate fluid during exercise. A fluid loss could reduce physical performance, especially during high-intensity training and could also cause fatigue. Athletes need to maintain adequate fluid levels pre-, during, and post-exercise to prevent thermal stress, delay fatigue, and reduce the risk of injury related to dehydration and sweat loss. The water helps the body to compensate for fluid loss through sweat (Carvalho, 2007). Sports drinks consisting of energy sources and electrolytes such as carbohydrates and sodium, respectively, were more effective in enhancing performance compared to water (Ford, 1999; Shirreffs, 2009). Sports drink was often used to compensate for fluid loss, maintain blood glucose levels, rebalance fluid levels, and replenish different enzymes and salts close to the normal level (Shalesh *et al*., 2014).

Sports drink provides electrolytes (Aziz *et al*., 2016), carbohydrates and fluid (Simulescu *et al*., 2019) which could help to replenish the loss of fluid and electrolytes in the body during exercise and help the thermoregulation process. It provides a rapid carbohydrate supply to the body which would give more energy and fuel during exercise (José and José, 2015).

Healthy food and drinks have become a current trend due to the increase in consumers' awareness. Athletes, especially, require healthy food and drinks from natural sources which are expected to meet their carbohydrate, electrolytes and fluid needs. Currently, there are some natural and functional foods that can be widely found on the market (Ozen *et al*., 2012). Thus, formulation for sports drinks from natural ingredients requires some development so that it would also be readily available in the market.

The interest in sports drink research has been increasing over the past years. Sports drinks with natural ingredients such as coconut water (Kalman *et al*., 2012), sugarcane extract (Kalpana *et al*., 2013) and beet (Muggeridge *et al*., 2014) showed effective results in athletes' performance. Furthermore, fruit-based sports drinks contain polyphenol, an organic compound commonly found in plants which could reduce muscle damage due to exercise and improve physical performance (D'Angelo, 2020).

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The mixture of pomegranate and grape extract was considered a fruit-based energy drink with high antioxidants, anthocyanin and ascorbic acid. The developed mixture was very soluble gave a good colour, and was used as an energy drink for soldiers in war environments (Shiby *et al*., 2013). The mixture of orange and whey extract showed an increase in the nutrient level in general. The experiment done at the household level could be commercialized as a healthy soft drink alternative and reduce biological oxygen levels. This drink had a refreshing and acceptable taste, also simple and economical (Pareek *et al*., 2014).

Sports drinks with a mixture of sugarcane and calamansi extract, and fructooligosaccharides provided comfort in the digestive tract during high-intensity intermittent exercise. This formulation reduced the headache problem during the study, although no significant difference was observed in the level of sweat, pulse, and perceived exertion during a trial (Chew *et al*., 2020). The development of sports drinks from pomegranate juice, cucumber juice, dextrose, chia seeds, and pink salt was considered an innovative drink. It contained 27.24 kcal of energy, 0.86 g protein, 44.58 mg potassium, and 101.75 mg sodium in a 200 ml serving size. The addition of 15 g sugar positioned the drink under the hypertonic beverage category (8 g sugar per 100 ml as carbohydrate). The hypertonic drink is an option to fulfil the energy and electrolyte intake after exercise (Bhardwaj and Saraswat, 2019). Based on the examples, this study focused on the formulation of sports drinks from Sidimpuan salak fruit, one of the most commonly found tropical fruits in Indonesia.

Salak can be eaten fresh or processed further into products such as pickles, sweets, chips, and juice. Salak has high carbohydrates and fibre, with low protein and fat content. Sodium, magnesium, potassium, and calcium are the minerals that can be found in salak fruit. It has high vitamin C (ascorbic acid) and antioxidants (Ismail *et al*., 2018), and other various nutrient contents. Salak contains various phytoconstituents and nutrition, such as sucrose (7.6 g/100 g), fructose (5.9 g/100 g), total sugar (17.4 g/100 g), dissolved-based fibres (0.3 g/100 g), non-dissolved fibres (1.4 g/100 g), total food fibres (1.7 g/100 g), water (80 g/100 g) calories (77 kcal/100 g), protein (0.7 g/100 g), ash (0.6 g/100 g) and fat (0.1 g/ 100 g). The salak fruit is a natural sugar and food fibre source (Saleh *et al.*, 2018). Based on the nutritional composition of salak, then salak has the potential to be developed into a natural sports drink. This study aims to develop a sports drink from the Sidimpuan salak fruit.

2. Materials and methods

2.1 Materials

The ingredients used for the formulation include flesh from fresh Sidimpuan salak fruit, water, salt, and glucose syrup. Salak was obtained from a local seller in Medan, while salt and high glucose syrup (Koepoe brand) were obtained from a market in Medan.

2.2 Preparation of Sidempuan salak sports drink

Preparing Sidimpuan salak sports drink (SSSD) involves several steps. First, 3 kg of salak fruit flesh is washed using running water, then soaked in hot water for 5 mins, and drained. Salak flesh was extruded using a slow juicer to produce salak fruit juice. Salak juice was filtered using eight (8) layers of muslin cloth to get salak juice without pulp. Different amounts were transferred into bottles containing 250 mL (SSSD1), 200 mL (SSSD2) and 150 mL (SSSD3) of salak juice, respectively. Following that, 10 mL of glucose syrup and 0.2 g of salt were added to each bottle. No water was added to SSSD1 and 50 mL and 100 mL were added to SSSD2 and SSSD3, respectively. The SSSD was stored in a refrigerator at a temperature of about 10-15°C until it was ready to be analyzed. The sports drink formulations are presented in Table 1.

Table 1. SSSD formulation.

Ingredients	Salak–water ratio		
	250:0 (SSSD1)	200:50 (SSSD2)	150:100 (SSSD3)
Sidempuan salak	250 mL	200 mL	150 mL
Water	0	50 mL	100 mL
Salt	0.2 g	0.2 g	0.2 g
Glucose syrup	10 mL	10 mL	10 mL

2.3 Sensory analysis

Sensory testing was carried out at the training ground on twenty Medan City futsal players, with an average age of 17 and male. Before the sensory test, the panellists received an explanation of the procedure for conducting the sensory test. During the sensory test, each athlete received 100 mL of SSSD. Panellists get a questionnaire to assess the colour, aroma, taste and texture of the SSSD. The assessment uses six (6) scales, i.e., dislike (1), slightly dislike (2), dislike or dislike (3), slightly like (4), like (5), and like very much (6), for evaluation (Bhardwaj and Saraswat, 2019).

2.4 Chemical analysis

Water content analysis was done using SNI 01-2891-1992 method, Point 5.1 (Gravimetric). Ash content was determined by SNI 01-2891-1992 method, Point 6.1 (Gravimetric). Total fat was determined by the IKP/K-1 (Soxhlet-Hydrolysis) method. Protein content analysis

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was done using SNI 01-2891-1992 method, Point 7.1 (Kjeltech) and carbohydrate using the IKP/K-3 (by difference) method. Total calories were determined by calculation. Sodium and potassium were determined by the IKP/K-7 (AAS) method. Total sugar was calculated using the IKP/K-2 (Titrimetric) method. Vitamin C assessment was done using KP/K-11 (HPLC). The entire chemical analysis was done at Mbrio Food Laboratory.

2.5 Statistical analysis

The data were analyzed using analysis of variance (ANOVA) and continued with the Least Significant Difference (LSD) test using IBM SPPS statistics 26 software.

3. Results and discussion

3.1 Sensory analysis

Organoleptic and hedonic analyses are presented in Table 2. This analysis was done to identify the panels' liking of the colour, aroma, taste and texture of the sports drink. Panels liked the colour of the drink. Panels commented that the drink was not sweet enough, although they liked the drink overall. The type and concentration of a drink are very dependent on consumers' perceptions (Shirreffs, 2009). Manipulating the sweet taste in fruit drinks could be done through the addition of sweeteners which would affect and suppress the intensity of the sour taste of the fruit. Glucose, sucrose, and oligosaccharides were proven effective in maintaining blood sugar levels and improve endurance during prolonged exercise (Aziz *et al*., 2016). The sensory analysis could be used to provide information on consumers' liking of the developed products (Cappelletti *et al*., 2015) and this could be useful for further development. Consumer acceptance helped to market the drink formulation to a bigger population (Iannario *et al*., 2012; Sciences *et al*., 2020).

Table 2. Sensory analysis by Medan City futsal players in Medan, Sumatera Utara.

Parameters	Colour	Aroma	Taste	Texture
Organoleptic	3.4±0.2	4.5±0.3	5.4±0.2	5.4±0.2

Values are presented as mean±SD.

3.2 Chemical composition

Chemical characteristics can be seen in Table 3, while total sugar and minerals analysis are shown in Table 4. A sports drink is consumed when exercise is involved, which could be pre-, during, or post-exercise. A sports drink contains water and various nutrients which could be an option for oral rehydration. Sports drink accelerates dehydration, stimulate faster fluid absorption, reduce physiological stress, and promote recovery post-exercise (Shirreffs, 2009). This drink contains carbohydrates, electrolytes, and vitamins and is intended for individuals doing physical activities (Navarro *et al*., 2016).

Sports drinks are consumed to obtain nutrient supplementation for athletes. Maintaining optimal electrolyte balance could improve rehydration while carbohydrates ensure continuous optimal energy. The addition of electrolytes and carbohydrates helps in fluid absorption in the intestine and replenishment of muscle glycogen, respectively. Gastric emptying became slower as a result of the rehydration drink (Sciences *et al*., 2020).

The SSSD formulation contained various amounts of water, ash, fat, protein, and carbohydrate depending on the amount of salak fruit extract added to the drink. The formulation with pure salak extract without a mixture of water gave the highest nutrient content and calories. The nutrient level of the drink decreased along with the reduced amount of the salak extract. SSSD contains sodium, potassium and vitamin C. The overall composition found in this drink could be used as a sports drink for athletes.

Fruit-based sports drink provide an excellent source of nutrients. Sports drinks with pomegranate and cucumber juice had high sodium and potassium, and the natural colour and taste helped in an improved appearance. This product helped in electrolyte replenishment and recovery post-exercise (Bhardwaj and Saraswat, 2019).

The water content in SSSD increased significantly along with the reduction in salak extract. The addition of 50 and 100 mL of water in SSSD1 and SSSD2 formulations, respectively, gave a higher water content to both formulations. The water content of natural sports drinks was very dependent on the water content found in the natural sources, in this case, the fruit. The water content of a sports drink formulated from coconut water would be higher than melon juice due to the higher water content presented in coconut water (Effiong and Udofia, 2018).

Ash content, total fat and protein in SSSD decreased as the amount of salak extract reduced. These compositions were observed to be the highest in SSSD1 formulation, compared to SSSD2 and SSSD3. Ash content in the SSSD1 formulation was significantly different from SSSD3, although no difference was observed when compared to SSSD2. The amount of salak extract affected the decrease in ash content, total fat, and protein in the drink as the main source of these compositions came from the fruit.

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Table 3. Chemical composition of SSSD formulation.

Sidempuan Sports Drink Formulation	Water content (g/100 mL)	Ash content (g/100 mL)	Total Fat (g/100 mL)	Protein (g/100 mL)	Carbohydrate (g/100 mL)	Total Calories (kcal/100 mL)
SSSD1	84.95±0.2[a]	0.33±0.05[a]	0.31±0.01[a]	0.52±0.05[a]	13.88±0.2[a]	60.43±0.5[a]
SSSD2	87.40±0.5[b]	0.21±0.06[ab]	0.25±0.04[a]	0.46±0.05[a]	11.57±0.6[b]	50.79±1.7[b]
SSSD3	89.99±0.6[c]	0.20±0.07[b]	0.27±0.05[a]	0.49±0.08[a]	9.04±0.6[c]	40.60±2.3[c]

Values are presented as mean±SD of triplicates. Values with different superscript within the same row are statistically significantly different ($p<0.05$).

Table 4. Total sugar, minerals, and vitamin C content in SSSD1.

Total Sugar	Sodium	Potassium	Vitamin C
10.34±0.33	12.75±2.5	100.11±3.8	10.62±0.07

Values are presented as mean±SD of triplicates.

The highest level of carbohydrates and calories was observed in SSSD1. The salak extract to water ratio affected the nutrient levels in the formulation. The composition of carbohydrates and calories in SSSD reduced significantly with the reduced amount of salak extract added to the formulation. Calories on the drink were obtained from carbohydrates, fat and protein. Glucose and other types of carbohydrates stimulate water absorption. Thus, higher water retention and lower diuretic effect could be achieved in a trial on carbohydrate-electrolyte drinks (Wong and Chen, 2011). Carbohydrates delayed gastric emptying and supplied energy during exercise (Shirreffs, 2009).

The SSSD1 drink contained sodium and potassium which were obtained from the addition of salt and the salak extract, respectively, as salak is a good source of potassium. Sodium and potassium have important roles in a physiological process. Potassium is important for muscle functions as it plays a key role in the contraction of smooth muscles. Sodium and potassium together help to adjust fluid and electrolyte balance. Both played an important role in muscle cell membrane depolarization (Pohl and Wheeler, 2013).

Prolonged exercise could induce acidosis and fatigue. Thus, sodium consumption as a potential buffer has been recommended to prevent metabolic acidosis and improve anaerobic performance. Sodium modifies the peripheral fatigue index to improve exercise performance (Chycki *et al*., 2018). Consumption of carbohydrate-electrolyte drinks increases the fluid level within the vascular compartments. Higher fluid retention due to the carbohydrate present in the carbohydrate-electrolyte drink stimulated higher fluid absorption in the intestines. The presence of sodium in the drink lowered diuresis by minimizing the reduction of plasma osmolality. Glucose provides the gradient between the active transport of sodium and the transport of the molecules (Wong and Chen, 2011).

Vitamin C in drinks plays a vital and specific role in metabolism, where the lack or excess of it could cause health problems. Vitamin C is a water-soluble vitamin, that acts as co-enzymes under normal biological function (Navarro *et al*., 2016). Vitamin C reduces oxidative stress-induced during exercise and lowers the ROS level arising from exercise (Braakhuis, 2012). Vitamin C prevents tissue damage caused by free radicals. Exercise could induce oxidative stress, muscle tissue damage, lipid peroxidation in the membrane and the formation of free radicals. Hence, nutrient supplementation was recommended for athletes to prevent the negative effects of exercise. Optimal nutrients could help in recovery post-exercise (Patlar *et al*., 2017) and could be achieved through sports drink consumption.

4. Conclusion

Each formulation of Sidempuan salak sports drink (SSSD) contains different nutritional composition values, in which SSSD1 ash content, carbohydrate content and total calories were significantly different from SSSD2 and SSSD3. SSSDs can potentially be a source of carbohydrate sports drinks, which can help meet athletes' calorie needs quickly.

Conflict of interest

The authors declare no conflict of interest that could have appeared to influence the work reported in this paper.

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