

Evaluation of nutritive values and consumer acceptance of sweet corn (*Zea mays*) juice as a recovery beverage for exercising people

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Abstract

Carbohydrate-protein (CP) drinks have been shown to exert better effect in promoting faster muscle recovery and rehydration in exercising individuals. However, not all active people, particularly Asians can consume milk-based CP drinks that would trigger symptoms of lactose intolerance and discomfort. Thus, this study aimed to assess the feasibility of sweet corn (*Zea mays*) beverage as an alternative recovery drink for active people due to its high content of carbohydrate and protein as well as lactose-free. The first phase of the study was the formulation of sweet corn juice that match the specific criteria for an effective recovery drink. Next, the study on the acceptance assessment of the new formulated sweet corn juice was conducted. The results show that the product contains high carbohydrate and protein contents which met the criteria for recovery beverage for active people. Besides, the results of sensory and hedonic evaluation demonstrate that the product was well-liked and accepted by majority of the consumers. To conclude, sweet corn juice which is lactose-free may offer extra benefits in such a way that it will provide alternative recovery drink that can be consumed by lactose intolerant active people.

Keywords: Sweet corn, beverage, nutrient composition, exercise

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INTRODUCTION

It is common for active individuals to experience hypohydration and muscle soreness particularly after vigorous exercises. Therefore, effective recovery is important to prepare the body for the next session of exercise. Recovery consists of muscle glycogen restoration, fluid loss replacement, and muscle repair. Studies showed that muscle glycogen could be restored within 24 hours when sufficient amount of carbohydrate are ingested (Beelen *et al.*, 2010), while recovery process shows better result when protein is ingested together (Burke *et al.*, 2004), thus helps in alleviating muscle soreness (McBrier *et al.* 2010).

Currently, the recovery beverages industry shows consistent encouraging growth due to the constant high demands in the market, particularly among the athlete population. For instance, sales of Gatorade sports drink in 2015 was amounted to USD1.67 million in the US alone (The Nielsen Co, Dr Pepper Snapple Group Inc. 2016). In Malaysia, some of the popular brands of commercial recovery drinks including Horleys high protein shake, Shaklee ESP Soy Protein, Nestle MILO chocolate malt beverage, and Gatorade sport fuel protein shake. All of these products are milk-based except for Shaklee ESP Soy Protein which is plant-based. Many studies conducted among Caucasian athletes showed that milk-based beverages are effective post-exercise drinks due to rich contents of carbohydrate, protein, vitamins, and electrolytes (Karp *et al.*, 2006; Shireffs *et al.*, 2007; Lee, Maughan & Shirreffs, 2008; Watson *et al.*, 2008; Cockburn *et al.*, 2010).

Unfortunately, milk-based drinks are not the best choice for active people who suffer from lactose intolerance as ingesting products containing lactose will result in unpleasant symptoms such as bloating, nausea, diarrhea, and vomiting which may interfere with sports performance. A study done by Asmawi and colleagues (2006) have

shown that the prevalence of lactose intolerance was high in Asian population with 88% in Malays, 91% in Chinese, and 83% in Indians. Similarly, more than half of the studied population in Thai (Densupsoonton *et al.*, 2004) and Singapore (Bolin *et al.* 1970) suffer from this digestive problem. Pelly & Burkart (2013) conducted a survey on dietary regimens among athletes competing in 2010 Commonwealth Games in Delhi reported that 10% of the athletes from South East Asia countries were likely to follow a low and/or lactose-free diet to avoid the symptoms of lactose intolerance. Based on this statistic, it is imperative for manufacturers and researchers to produce lactose-free recovery beverages.

This study aimed to develop and assess the feasibility of a beverage from sweet corn (*Zea mays*) as an alternative recovery drink for active people due to its high content of carbohydrate and protein as well as lactose-free. This study also aimed to examine the acceptance of sweet corn juice among exercising people. It was hypothesized that the nutritive values of sweet corn juice are equivalent or at least at par with current recovery drinks and will be accepted as an alternative post-exercise beverage among exercising individuals.

MATERIALS AND METHODS

This study was divided into two phases which were the assessment of nutritional content of sweet corn juice and the sensory evaluation of the product. The participants signed the informed consent upon agreeing to be involved in this study. The procedure was carried out in accordance to the Declaration of Helsinki. All participants were habitual juice consumers, free from food allergies, and were willing to try the sample. This study protocol was reviewed and approved by Universiti Pendidikan Sultan Idris Research Committee.

Analyses of nutritional content of sweet corn (*Zea mays*) juice

Zea mays cooked corn kernel (N28-Nelson’s Franchise Sdn. Bhd.) was chosen to be used in this study. This species has its own sweetness taste and it is been planted locally by Nelson’s company make it available throughout the year. Referring to the nutrient analysis provided by the manufacturer, the amount of commercially frozen *Zea mays* kernels was calculated to match the recovery drink formulation as suggested by the previous study (Beelen *et al.*, 2010). Using slow juicer, *Zea mays* juice was extracted with additional of 3g of salt and 300ml of plain water.

Chemical assays for nutritive values of the sample were carried out in the Analytical and Nutritional Labelling Laboratory of Universiti Kebangsaan Malaysia (UNIQEP Sdn. Bhd., Selangor). Calorie, carbohydrate, total protein, and fat were identified according to the in-house method described by Association of the Official Analytical Chemists (AOAC), 16th edition (1995). Types of sugar and amino acid present were identified using high performance liquid chromatography (HPLC) method (Waters 2475, United Kingdom) while Atomic Spectrophotometer (AAS) (GBC Elite 906AA, United Kingdom) was used to calculate the sodium content.

Sensory analysis and consumer acceptance

Before conducting the sensory evaluation on the sample, a total of thirty male and female volunteers were asked to fill in the modified Product Acceptance questionnaire (Song, 2013) to determine the validity and reliability of the questionnaire. The value of Cronbach’s alpha was 0.804, which is high reliability according to Cohen (1988).

Then, another 41 untrained adult panelists were selected for sensory evaluation of the sample. The participants were involved in physical activity more than 3 times per week at least 30 minutes each session and had an experience of recovery drink consumption. After tasting the sample which was served chilled (4°C), the participants were asked to rate the sample based in its appearance, color, aroma, taste, texture, mouthfeel, and overall like using the 9-point hedonic scale (from 1=dislike extremely to 9=like extremely). The participants were also required to answer three questions regarding the product acceptance, intent to purchase, and whether they will consume the product after exercise.

Next, the consumer acceptance test was conducted at public places in Tanjung Malim and Kuala Lumpur. A total of 429 participants were voluntarily involved in the taste test and answered the product acceptance questionnaire.

Data analysis

Data of the study were analyzed using SPSS 23.0. Descriptive statistics such as mean, standard deviation, percentage, and frequency were used to report the feasibility and acceptance of the product. Besides, a two-phase cluster analysis was conducted to identify the amount of groups where the participants have similar response towards the sample. The significant value was set at p<0.05.

RESULTS AND DISCUSSION

Nutritive values of the sweet corn (*Zea mays*) juice

Table 1 shows the nutrient contents of the sweet corn used in this study. The juice contained 57 kcal energy, 68.8% carbohydrate, 16.8% protein, 14.2% fat, and 64.3 mg sodium in 100 ml sample.

Table 1 Nutritive value of sweet corn (*Zea mays*.) juice.

Nutrient	Value (100 ml)
Calorie (kcal)	57
Carbohydrate (g)	9.8
Protein (g)	2.4
Fat (g)	0.9
Sodium (mg)	64.3

The types of sugar and amino acids present in the sample are as shown in Table 2. Fructose and glucose contents were in fair amount with about 0.18g and 1.8g, respectively. Sixteen amino acids present in

substantial amounts with the highest contents recorded were alanine (0.395 g), glutamic acid (0.394 g), proline (0.232 g), and leucine (0.198 g).

Table 2 Types of sugar and amino acid in 100 ml sample.

Nutrients	Amount (g/100ml)
<i>Types of sugar</i>	
Fructose	0.18
Glucose	1.8
Sucrose	<0.01
Maltose	<0.01
<i>Types of amino acids</i>	
Aspartic Acid	0.129
Serine	0.134
Glutamic acid	0.394
Glycine	0.087
Histidine	0.040
Arginine	0.103
Threonine	0.072
Alanine	0.395
Proline	0.232
Thyrosine	0.082
Valine	0.137
Lysine	0.013
Isoleusine	0.052
Leucine	0.198
Phenylalanine	0.088
Cysteine	0.188

Sensory evaluation and consumer acceptance

Table 3 shows the responses for seven attributes rated by 41 untrained panelists. Most of the panelists liked the color and aroma of the sample followed by other remaining attributes.

Table 3 Frequency and percentage of panelists response for Likert Scale 6-9 (Like slightly to Like extremely) for sensory attributes of the sample.

Attributes	Response
Appearance	31 (75.6%)
Color	37 (90.3%)
Aroma	33 (80.5%)
Taste	26 (63.5%)
Texture	32 (78.0%)
Mouthfeel	31 (75.6%)
Overall like	32 (78.0%)

Figure 1 shows the diagram of spider web for sensory evaluation of the sample. It demonstrates the intensity for each attribute which was well accepted by all panelists.

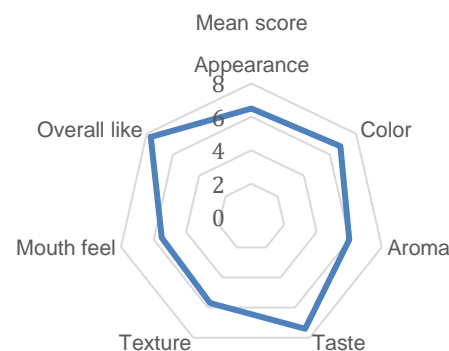


Figure 1 Typical spider plot for intensity of attributes in the sweet corn juice among the untrained panelists.

To determine the consumer acceptance towards the product, a two-phase cluster analysis was conducted among 429 consumers. There

were two clusters formed for the seven attributes being studied. The size of the largest cluster consists of 244 (56.9%) consumers and the smallest size was 185 (43.1%) consumers with the ratio of 1.32.

Table 4 demonstrates that the mean score for each attribute was significantly higher ($P < 0.05$) in cluster 2 (largest cluster) compared to cluster 1 (smallest cluster), indicating that consumers in cluster 2 well-liked the product, while consumers in cluster 1 disliked the juice. Based on the survey conducted, 75.5% of the consumers said that the product is acceptable, 53.4% of them were willing to buy the product if it is commercially available, and 54.8% of them would consume the product after exercise.

Table 4 Comparison of mean score for 7 attributes between clusters.

Attributes	Cluster	
	1 (n=185)	2 (n=244)
Appearance	4.92	7.14
Colour	6.24	7.48
Aroma	4.65	6.82
Taste	3.48	6.70
Texture	4.50	6.94
Mouthfeel	3.68	6.74
Overall like	4.17	7.06

The chemical assays showed that the sweet corn juice in the present study contained high carbohydrate and protein and a fair amount of sodium which were comparable to the nutrient contents of commercially available recovery beverages (Desbrow *et al.*, 2014). In addition, results from sensory evaluation and consumer acceptance study demonstrated that the attributes in the sweet corn juice was accepted by the consumers.

Our product contained approximately 68.8% carbohydrate, 16.8% protein, in 100 ml sample. The values were quite similar to the sample used in Trikoondun and Leenanon (2016) study which comprised of 60.06% carbohydrate and 13.31% protein. The sugar contents (combination of fructose, glucose, and others) of the sweet corn juice was comparable to several corn products. For example, sweet corn with kernel cut off cob contains 2.5 g sugars per 100 g corn. In another boiled sweet corn with kernel on cob contains 3.78 g/100 g sample (USDA Nutrient Database, 2011). Meanwhile in our product, the total sugar is 1.06 g per 100 ml sample. The difference in carbohydrate, protein, and total sugars may be due to different preparation methods or different variety of the corn itself. Regardless, the sweet corn contains high sugar content that contributes to the sweetness of the product. Besides, sweet corn is categorized as moderate to low glycemic index (GI) food, with GI values ranged from 37 to 62 (Atkinson *et al.*, 2008). It has been suggested that this GI food group could fasten the recovery process (Burke *et al.*, 2011). Therefore, sweet corn juice is suitable to be used as recovery beverages for quick muscle glycogen replenishment.

Carbohydrate and protein are essential for the post-exercise recovery. According to Beelen *et al.* (2010), carbohydrate intake of 1.2g/kg body weight could restore the loss glycogen to an optimal level. Assuming that an athlete body weight is 50 kg, he will need 60g of carbohydrate to achieve an optimal recovery effect (Beelen *et al.*, 2010). In our study, sweet corn juice contained 9.8g carbohydrate per 100 ml juice. Therefore, theoretically, the athlete needs to consume approximately 612 ml of this juice to restore the glycogen.

It has been suggested that different types of carbohydrate promote glycogen replenishment due to multiple carbohydrate oxidation pathways. Glucose and fructose utilize a different transport pathway to enter body cell and replenish glycogen storage after exercise. Our product contains a fair amount of glucose (1.8g/100 ml) and fructose (0.18 mg/100 ml). Theoretically, by combining these two types of sugar, this will improve carbohydrate absorption and increase the energy supply (Gonzalez *et al.*, 2017). However, this assumption is yet to be established and further research is warranted to examine whether sweet corn juice could enhance sport performance.

Beelen and colleagues (2010) also have proven that consuming both carbohydrate and protein could result in synergistic effect on muscle recovery. Amino acid has been shown to enhance muscle protein synthesis and restore net protein balance which contributes to muscle recovery after exercise (Phillips & Van Loon, 2001; Reidi *et al.*,

2014). Branched-chain amino acid (BCAA) can be oxidized in skeletal muscle when sufficient protein is available. It has been discovered that BCAA such as leucine, isoleucine, and valine have beneficial effects in reducing exercise-induced muscle damage effects and promoting muscle-protein synthesis (Negro *et al.*, 2008).

The present study indicated that the sweet corn juice contained 16.8% protein which comprised of 16 amino acids in total. Alanine made up the highest proportion with 0.395 g per 100 ml sample, followed by several BCAA which were leucine (0.198 g/100 ml), isoleucine (0.052 g/100 ml), and valine (0.137 g/100ml). In most of commercially available BCAA supplements, at least 5 g of BCAA is needed to produce the beneficial effects of BCAA supplementation. Meanwhile, the suggested ratio for leucine:isoleucine:valine is 2:1:1 or 3:1:1 (Kephart *et al.*, 2016). Similar ratio of the BCAA amino acids was obtained in this study which was 2:1:1. Therefore, this finding showed that our product has the potential to be developed as an alternative source of BCAA for muscle recovery purpose.

Sensory evaluation and consumer acceptance findings showed that the sweet corn juice ranked between 6.70 and 7.48 in a 9-point hedonic scale, indicating that the product is well-liked and satisfactorily accepted by majority of the consumers. Looking at the individual attributes, color of the sample was ranked the highest by the consumers, followed by appearance, aroma, overall liking, texture, mouthfeel, and taste. It is not surprising that color and appearance top the lists because they are the most noticeable attributes that create human expectation towards the taste of a product (Vilela & Cosme, 2016). In producing the sweet corn juice, no artificial was added into the formulation. Hence, the color that attract the consumers was attributed by the natural color of the corn. On the basis of this result, the manufacturers should focus on the color of a product as a marketing strategy to gain the consumers' attention.

Despite the high preference for the appearance of the product, the consumers ranked the taste of the corn juice as the lowest attribute. The bitter and unpleasant flavor perceived by the consumer could be contributed by the addition of sodium into the beverage (Leiper, 2015). Although sodium or table salt is proven to enhance the taste or flavour of food (Institute of Medicine, 2010), adding too much sodium could suppress the sweet taste of the corn kernels. In the current work, sodium was added in the formulation as in most recovery beverages, sodium plays important roles in promoting water retention and accelerating the rehydration process (Stachenfeld, 2008). Thus, more work needs to be done to reformulate the sweet corn juice that is not only effective in rehydrating during strenuous activity, but also has pleasant taste that are favored by the consumers.

Consumers were inquired about the acceptance of the product, intention to purchase, and whether they will consume the product after performing strenuous physical activity. The findings indicated that more than half of the consumers were interested in purchasing and consuming the product if it is commercially available in the market.

CONCLUSION

The sweet corn juice developed in this study provides high contents of carbohydrate and protein which are vital in enhancing rehydration and muscle recovery during and after training. Additionally, this product has received good acceptance from the participants. Future works are required to elucidate whether sweet corn juice is as effective as commercially available recovery beverages in terms of its capabilities to replenish energy and reduce muscle damage.

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