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Original Research Article

Utilization of Sweet Potato in Development of Boba

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Abstract: Commercial substance in a drink, known as boba or bubble tea, is extensively consumed by all generations from children to the elders and various societies. Boba, which are known as tapioca pearls are originally made up of tapioca starch and then served with milk tea. This sweet potato pearl has lower calories than tapioca, which can give benefits to the consumer since it has a lot of nutritional value such as high β-carotene, rich in vitamin C, high value of dietary fiber, antioxidants level and protein content. Therefore, in this research, sweet potato flours were prepared in three varieties to make boba pearls, where: (1) sweet potato flour was substituted with 50% sweet potato flour and 50% tapioca flour, (2) 100% sweet potato flour added with fish gelatin; (3) 100% sweet potato flour added with bovine gelatins. These substitutions affected the physicochemical properties of the mixture such as pH and textural properties chewiness and chewing energy. According to the result, boba containing fish gelatin showed lower chewing energy with 217.678±3.8 g of chewiness and 4136.833±39.1 g.%, therefore suitable for all level of generations. Through this finding, boba lovers are able to consume boba safely without any possible choking incidences and indigestion as claimed by other critics of boba consumption.

Keywords: boba; sweet potato; tapioca pearls; beverages

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1. Introduction

Boba, known as tapioca balls or tapioca pearls are originally discovered from Taiwan in the early 1980s and gained by removing starch from tapioca. But lately, there has been an ascent in the trend, where people from all generations feel the "addiction" and "pleasure" when chewing a soft texture pearl shape of boba in their mouth. Commonly, bobas will be served with milk tea which known as Bubble Milk Tea (BMT). BMT become one of young generations favorite drinks as abundant franchises with different brands were opened all over Malaysia.

Sweet potato (*Ipomoea batatas*) is perennial shrubs that originate in the tropics of ideal continent of America, which is planted in sandy soils or soil that contain high absorption of water (Mohd Zahari *et al*., 2014). Sweet potato has the characteristics, which large in size, starchy, originally sweet-tasting and tuberous root where their shoots or young leaves usually can be eaten as greens (Williams & Ammerman, 1968). Sweet potatoes were normally found in orange fleshed color that playing important roles in human health.

Sweet potato is important crop for developing countries by their growing period where this sweet potato required a short period of growing which usually in 90–120 days (Mohd Hanim *et. al*., 2014). Besides being one of the basic foods in certain country such as Soloman Islands, this sweet potato plays a very important roles in human diets, where they consist of high nutritional value. These nutritional qualities are mostly required and meeting nutritional need by humans such as carbohydrate, fiber, vitamin A and C and high protein contents (Mais & Brennan, 2008).

According to Mohd Hanim *et al*. (2014), in Malaysia, according to the tubers crop popular ranks, sweet potato is the second most popular next to tapioca and has been developed on a small scale since 17th century. It is usually being used as one of basic ingredients in producing snacks and commonly well known in traditional confectionery such as *onde-onde*, *bingka* and *keria*. Maleki (2001) stated that this sweet potato can be used as supplementary food for infants and can be compared to other cereal baby foods that usually contain wheat that may cause hypoallergenic effect to babies. This statement is supported by Sarmin *et al*. (2016) that added sweet potato as free-gluten content that contributes to allergic and digestion problems to the babies.

Sweet potato contains high nutritional value that can give many benefits to human being. Higher dietary fiber content of sweet potato as reported by Mohd Hanim *et al.* (2014), whereby consuming it can give huge impact on eaten food by reducing the rate of glucose breakdown and absorption. Besides, this huge impact helps to ensure the glucose level in body maintaining a normal blood sugar level and helps to facilitate a steady breakdown of carbohydrates (Brennan & Samyue, 2004).

Moreover, according to a study conducted by Aprianita *et al.* (2009), they found that sweet potato is suitable to be used in food products that require continuous thermal processing such as food for children and the elderly. This may due to the presence of high protein content that prolonged the starch swelling process and increase in velocity. Continuous thermal processing products are defined as products that undergo a process with combination of temperature and time required to eliminate a desired number of microorganisms from a food product continuously. For example, baby food products required continuous heating process to ensure microorganisms in food is killed and food products safe to be consumed.

In practicing a healthy lifestyle, the ingredients used to make boba, which is from tapioca can be replaced by using sweet potato. 60 grams of sweet potatoes can be converted into approximately 54 calories, which is lower than the calories in tapioca. Besides, the fiber content in sweet potato is insoluble that promotes insulin regulating the amount of sugar in blood of diabetes patients Another important benefits of utilizing sweet potato has moderate value of glycemic index, which is 54 that lies in medium GI, compared to tapioca that has value of 85, which falls into high GI value (Ebere *et al.*, 2017). This would benefit those existing patients and dieting patients to refrain from consuming food with lower glycemic index value and lower calories.

This study is aimed to develop a formulation of boba by using sweet potato and to investigate and compare the textural properties and sensory analysis of boba from mixture of sweet potato flour, tapioca flour and gelling agent.

2. Materials and Methods

2.1 Raw Materials

The sweet potato flour (Azuri, Malaysia) was purchased from a bakery shop located at Subang Jaya, while tapioca flour (Cap Kapal ABC, Malaysia) was bought from nearby supermarket. Fish and bovine gelatins were obtained from supplier (Phywon System Ingredient Sdn. Bhd., Malaysia).

2.2 Preparation of Boba

The sweet potato flour was mixed formulated with tapioca flour and gelatin, which function as gelling agent. The formulations of the mixture are shown in Table 1. There were three important steps in boba preparation.

Firstly, sweet potato flour, tapioca flour and gelatin powder were weighted into a bowl into three different flour mixture percentages. Then, 50 mL of filtered water was boiled inside a small size pot until it reached boiling point, 100^{o}C. Next, pour 13.2 mL of boiled water slowly, while stirring continuously by using a spoon until they started to stick together. Then, each flour-mixture was kneaded using hands to produce a thick dough.

The thick dough was rolled and cut into five mm long batons. The batons were rolled between palms to make a round shape bobas.

Finally, 200 mL of filtered water was boiled again in a medium size pot. The raw boba were placed slowly into the pot as the water boiled vigorously. The boba were stirred continuously until they were completely tender. The boba werecooked around 15 min to ensure the boba were fully cooked. Then, the cooked boba were strained by using a scoop and poured into a plate to let them cool off. The cooled boba pearls were then kept inside an airtight container and stored at room temperature until further process took place.

Table 1. Formulation of boba.

Sample	Formulation of boba mixture	Mass of sweet potato flour (SPF) (g)	Mass of tapioca flour (g)	Mass of fish gelatin (g)	Mass of bovine gelatin (g)
A	50 % SPF*	10.0	10.0	0.0	0.0
B	100 % SPF*	20.0	0.0	0.0	1.0
C	100 % SPF*	20.0	0.0	1.0	0.0
D	Commercial boba				

*SPF: sweet potato flour

2.3 Determination of pH Value

Determination of pH value was following the method by Ashogbon (2012). Each of different formulation ratio with total weight of five g was filled into a beaker and mixed with 20 mL of distilled water. The resulting suspension was stirred for five min and left to settle for ten min. The pH of the supernatant was measured by using a calibrated digital pH meter (PB-10, Sartorius, Germany) in triplicates, to reduce reading error.

2.4 Determination of Textural Properties

The textural properties were determined by using Exponent Software that was installed in a texture analyser (TA-XT plus, Stable Micro System Ltd, United Kingdom). Data such as chewiness, stiffness and chewing energy were determined by the installed software. The probe used to determine all the properties as mentioned above was SMS/Chen-Hoseney Dough Stickiness RiData. Each produced boba pearl was placed under the texture analyser to measure the listed properties, which are chewiness and chewing energy. For each test, five bobas with the same weight were chosen to be tested in triplicates.

2.5 Determination of Water Holding Capacity (WHC)

One g sample was added with 5 mL of distilled water and vortexed for one min to ensure the sample and water were mixed homogenously. Next, the mixtures were centrifuged for 10 min at 3000 g at room temperature in a centrifuge (Universal 320, Hettich Zentrifugen, Germany). The supernatant was then decanted carefully and the mass left in the tube was measured using the electronic balance. The water holding capacity was calculated using the formula below:

$$\text{Water holding capacity (WHC)} = \frac{(W_2 - W_1)}{W_0} \quad (1)$$

where W_0 is the weight of the sample; W_1 is the sum of weight of centrifuge tube and sample; W_2 is the sum of weight of centrifuge tube and sediments.

2.6 Sensory Analysis

Sensory analysis with 9-hedonic points analysis type was done for all the samples A, B and C prepared in the lab and sample D was bought from an online store. The analysis was conducted by the participation of ten un-trained panelists who were randomly selected among students at Faculty of Engineering, University Putra Malaysia. This analysis was carried out to analyze consumer's acceptability on several criteria such as appearance, texture, taste and chewiness. The analysis additionally asked the panelists on which test they like the most, why they like the chosen test and finally, will they consider to change their preferences to the sample they have chosen.

3. Results and Discussions

3.1 pH Value

Table 2. The pH value of formulation boba

Sample	pH
A	5.50 ± 0.025
B	5.71 ± 0.023
C	5.41 ± 0.005

Based on Table 2, the pH of three different formulations of sweet potato flours ranged from 5.41–5.71 were categorized as low acidic. Besides, this range of pH value is accepted as the common pH value of sweet potato flour is 5.6 pH as reported by Adeleke and Odedeji

(2010). Sample B was the lowest acidic as the present of bovine gelatin, which its pH value is categorized as alkaline as it undergoes alkaline hydrolysis. Sweet potato generally contains 37% of ascorbic acid as stated by the United States Department of Agriculture (USDA, 2012), therefore this might be the reason why sweet potato flours are slightly acidic. Adeleke and Odedeji (2010) stated that acidic products tend to have a longer shelf life as the food spoilage bacteria do not grow in acidic condition. This statement then is proven by Smith and Stratton (2007) claimed that a pH of 4.6 or lower, will not support the growth of Clostridium botulinum in food preservation that extends shelf- life of product to longer duration.

3.2 Chewiness and Energy Needed to Chew

Chewiness is the energy required to chew a solid food until it is ready for swallowing. Figure 1 and Figure 2 show the graph of chewiness, g and graph of energy needed to chew, g. % of four samples, which A represents 50% SPF and 50% tapioca flour, B represents 100% SPF with added of bovine gelatin, C represents 100% SPF with added of fish gelatin and D represents commercialized boba. Commercialized boba were compared to the formulated boba in three readings.

Sample C that was formulated using 100% SPF and added with fish gelatin shows the best result, where the chewiness value was 217.678±3.803 that give the lowest value compare to others result, hence it required the least energy to chew, 4136.833±39.08382. Samples A and B with chewiness value of 254.287±5.483 and 240.43±7.114, respectively, have almost same range of energy needed to chew, which lies between 4400–4600 g.%. Despite of the observed differences, samples A, B and C were better compared to sample D based on the tested parameters

According to Figure 2, the energy needed to chew for sample B and C, which combination of sweet potato and gelatin (i.e. bovine or fish gelatin), exhibited significant difference. The energy needed to chew for sample C was lower with value of 4100–4200 g.% compared to sample B, which required 4400–4600 g.%. Despite of adding the gelling agent to both samples (i.e. samples B and C), sample C with the addition of fish gelatin consume less chewing energy due to lower melting point than bovine gelatin. Lower melting point affects the energy to chew as when the gelatin exposed to heat, the gelatin started to spread makes the gelatin thinner and easily to mix homogenously with the flour.

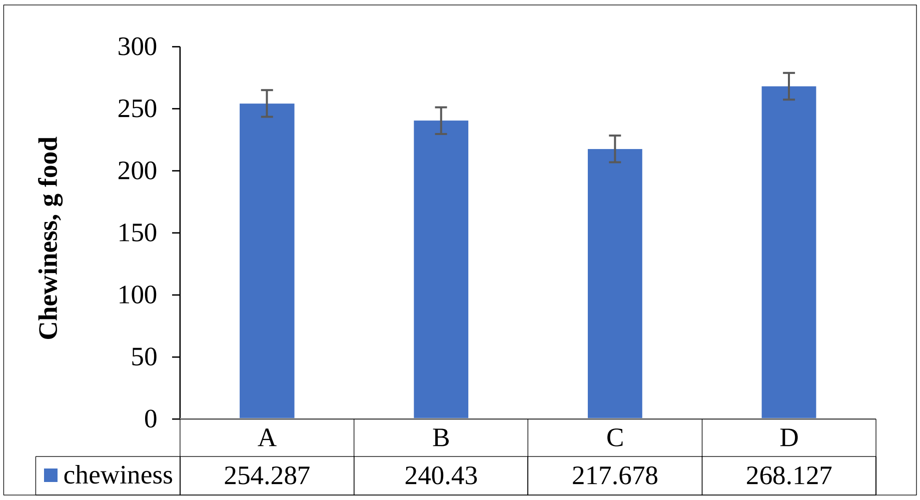

Figure 1. Chewiness of the sample.

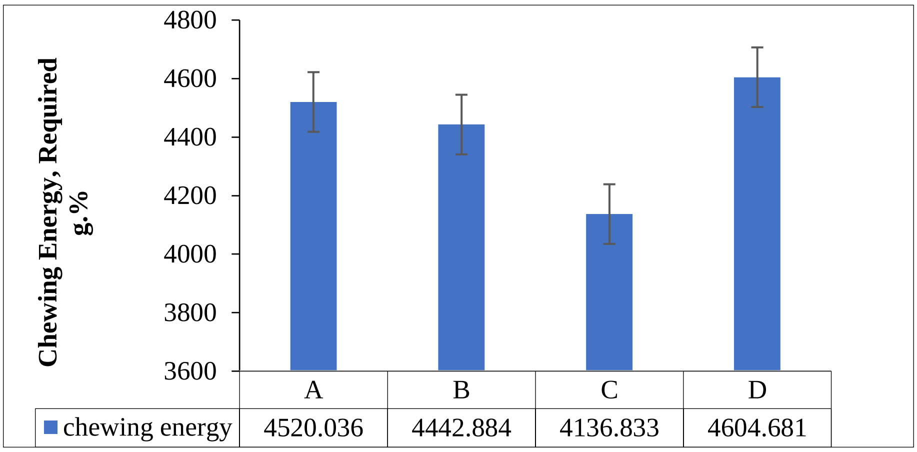

Figure 2. Energy needed to chew.

3.3 Water Holding Capacity (WHC)

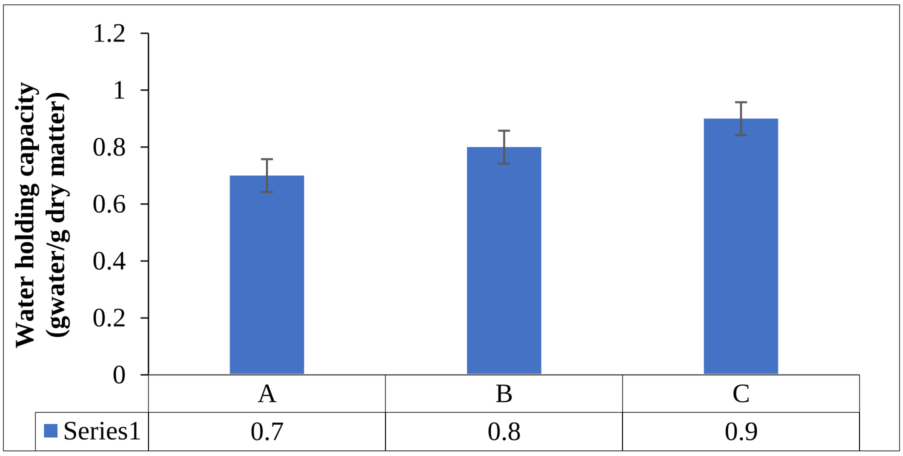

Figure 3. Water holding capacity (WHC) of different sample.

Figure 3 describes the water holding capacity of different samples at the same temperature, which in room temperature. The highest WHC was sample C with 0.9 g water/g dry matter, while sample A has the least water holding capacity, which is 0.7 g water/g dry matter.

According to International Starch Trading from Denmark, sweet potato contains higher amount of starch compared to tapioca. Therefore, contain higher amount of starch indicates higher amount of amylose and amylopectin content. Compared to tapioca, sweet potato has a little bit higher amount of amylose, which is 20%, while tapioca has 17% of amylose content. According to Liu (2005), starch gelatinization process started when the starch granules were exposed to heat in the presence of water that cause the molecular order to collapse within the starch producing irreversible changes. When the temperature of a suspension of starch granules in excess of water increases to the gelatinization temperature, the starch granule lost its bi-refringence and crystallinity, with concurrent swelling. This change is irreversible and called as gelatinization. The total gelatinization usually occurs over a temperature range (10–15°C).

3.4 Sensory Analysis

Table 3. Sensory evaluation of different formulation of boba.

Sample Labelled	Question based on appearance	Question based on taste	Question based on chewiness	Question on sample like the most
A	4.2	4.1	4.3	4.5
B	4.1	4.0	3.5	4.0
C	4.3	4.3	4.9	4.9
D	4.5	4.6	3.9	4.6

Table 3 shows the result of sensory evaluation obtained from 50 un-trained panelists. The results were measured using 5-point Linkert scale representing each question. The panelists were mostly in early adulthood categorized as boba lovers.

From the results obtained for questions based on “appearance” and “taste”, sample D placed as the highest rank, while sample B ranked the lowest. The result may due to the way of brown sugar being coated to the boba. Since sample D was bought from online store, the raw boba received have already been coated and dried well with brown sugar resulted to nice taste and attractive appearance with glossy look. The taste of boba was influenced by the amount of brown sugar that is caramelized during cooking. Most of the panelists chose sample D due to high amount of brown sugar used, while sample B is made with lower amount of brown sugar for health purpose and to satisfy the needs of the elderly and babies.

For questions based on “chewiness” and “the sample they like the most”, sample C hits the highest rank with 4.9 out of 5. Compared to sample D in term of chewiness, sample C is more accepted due to the present of gelling agent, which is fish gelatin. According to the result obtained, despite being loyal consumers of sample D, they chose sample C it is easier to chew and takes less energy to chew than other samples. In regards to the safety of consumers and its digestibility, the less chewy is the boba pearl, therefore, the higher chance of it to be ingested safely through the mouth until it reaches the guts. Therefore, sample C has been chosen as the best boba formulation that can be mass produced commercially to be marketed domestically and globally, as a health and comfort drink suitable for all ages (9-month baby to 75+ years old adult).

4. Conclusion

The result from this study signifies that the best formulation of mixture of sweet potato flour added with fish gelatin resulted to lower energy in chewing, therefore it is suitable for the youngest (age with partial teeth development) to the eldest generation in the society. The pH value of all samples tested in this study was low acidic, which can be one of benefits in longer shelf-life as bacteria that can spoil food is not able to grow in acidic condition. Sample C, which was made with formulation of sweet potato added with fish gelatin was ranked the highest, which were being preferred the most by all participated sensory panelists. Moreover, sweet potato has moderate value of glycemic index, which is 54 that lies in medium GI, compared to tapioca that has value of 85, which falls into high GI values (Ebere *et al.,* 2017). In the nutshell, this research has proven that sweet potato boba has many benefits than tapioca boba and can be safely consumed by all generations.

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