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Transforming liquids into pops of flavours by using Juice Pearl Kit

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Abstract

Bubble tea or pearl milk tea has become a part of modern food culture over the past decade. The original component of bubble teas is the black chewy pearls which have now evolved into various types of juice pearls so-called popping boba popular for its unique pop-in-the-mouth sensation once bitten. Juice pearls are produced based on a molecular gastronomy technique called spherification. This study aimed to develop an easy-to-use starter kit that consists of pre-mixed raw materials and a few basic pieces of equipment, that can be used for making instant popping juice pearls from any type of liquids samples such as soft drinks, milk, cordial, honey or fruit juice. Juice Pearl Kit is using a reverse spherification technique, where the liquid/beverage containing calcium is dropped into a water bath containing sodium alginate to form a liquid into small edible spheres or commonly named juice pearls. The application of reverse spherification is wider as it can be used with nearly any type of liquid. The developed Juice Pearl Kit consists of a syringe, bottle, forming trays, and pre-mixed spherification powders namely the AlgiBath and CalciGum. The preparation of juice pearls is divided into three steps, namely the preparation of AlgiBath solution and CalciGum solution, followed by the formation of the juice pearl. Juice pearls produced using Juice Pearl Kit are heat stable and show versatility in both iced and hot beverages. The developed production kit should provide a new alternative way for food processors in making unique and presentable foods and beverages, conveniently.

1. Introduction

Bubble tea, also popularly known as pearl milk tea is a Taiwanese tea-based beverage invented in the 1990s that sparked a worldwide food craze in the 2000s. Bubble tea's novelty as a trendy beverage lies in its versatility in a wide variety of flavours and its diverse combination of toppings. The original bubble tea is accompanied by chewy pearls (boba balls) which are made of tapioca, that are commonly added to hot or cold beverages, mostly in tea (Min *et al*., 2016).

Juice pearls (popping boba) have recently emerged as a favourite accompaniment to bubble tea due to their unique pop-in-the-mouth sensation once bitten. Juice pearls are widely used as ready-to-eat confectionery toppings for desserts and ice cream (Chua *et al*., 2018). Juice pearls are produced based on the molecular gastronomy technique called spherification. The principle of spherification consists of a controlled gelification reaction between two key ingredients (alginate and calcium salt) to form a gelatinous substance that will encapsulate liquid droplets into small liquid-filled pearls.

There are two types of spherifications namely basic spherification and reverse spherification. Basic spherification is where the liquid/beverage containing sodium alginate is submerged in a water bath containing calcium, whereas reverse spherification is where the liquid/beverage containing calcium is dropped into a water bath containing sodium alginate (Sullivan, 2019). Spherification is commonly used by chefs in the shaping of a liquid into small edible spheres in calcium-alginate capsules by applying the technique of gelation. According to Lee and Rogers (2012), this is the basis for the formation of faux caviar, eggs, gnocchi and ravioli.

Presently, all the juice pearls or popping boba available in the local market are imported mainly from Taiwan, China and Thailand. Among those well-known suppliers of juice pearls are from the brand Shan Dao, 18CTEA and Sunny Syrup from Taiwan, Yuan Zhen,

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Amber Boba and Hot Tran Chau Boba from China, and the Red Leaf Pearl from Thailand. For years, local food processors, chefs and home cooks have been asking a way to simplify the expensive spherification machinery into smaller-scale production and household uses.

During the International gastronomy conference held in Madrid Spain in 2009, there was a discussion about whether any gastronomy processes developed for food processing and large-scale catering could be adapted to domestic or restaurant kitchens. Innovation in culinary techniques has to be sufficiently simple to use, widely applicable, easily available and affordable, and in line with the main trends of the consumer market (Cassi, 2011). The new tools and devices that need to be developed must be considered to have wider applications, which can be found in nearly every kitchen.

Although the spherification process may seem simple, it is easily affected by factors such as surface tension and chelating reaction which will either cause the deformation of pearls into lumps of gel or failure of pearls to form. Getting the right conditions (acidity, alginate-calcium ratio, solution density, and viscosity) can be time-consuming and complicated (Lee and Rogers, 2012).

The objective of this study was to develop an easy-to-use starter kit that consists of pre-mixed raw materials and some basic equipment, that can be used for making instant popping juice pearls from any type of liquid samples. The developed production kit should provide a new alternative way for food processors in making unique and presentable foods and beverages, conveniently.

2. Materials and methods

2.1 AlgiBath and CalciGum pre-mixed powders

Works were carried out to optimize the formulation of two ready-to-use pre-mixed spherification powders, namely the AlgiBath and CalciGum with the main ingredients of alginate and calcium salt, respectively. All ingredients in this kit are common food-grade additives that are from halal sources and are safe for consumption. The pre-mixed AlgiBath powder (5 g) was mainly alginate salt, whereas CalciGum powder (40 g) was prepared by mixing calcium salt, sugar and food gum.

2.2 Production of juice pearls by using the Juice Pearl Kit

Besides the AlgiBath and CalciGum pre-mixed powders, the Juice Pearl Kit also consist of a syringe, bottle, forming trays, strainer and measuring cup (Figure 1). Based on the principle of reverse spherification, instructions are provided to simplify the preparation of 'custom-made' juice pearls. Larger size pearls can also be prepared by using a tablespoon. The preparation of juice pearls is divided into three steps, namely the preparation of AlgiBath solution (A), preparation of CalciGum solution (B) and the pearl formation.

Figure 1. Juice Pearl Kit and its content

2.2.1 Preparation of AlgiBath solution (solution A)

The AlgiBath solution (A) was prepared by filling the plain water at room temperature in a bottle up to the level of 400 mL. The AlgiBath powder was added to the bottle and shaken well until dissolved or mixed with a blender. The solution was left for 30 mins until it becomes clear.

2.2.2 Preparation of CalciGum solution (solution B)

The CalciGum solution (B) was prepared by mixing the CalciGum powder with 140 – 150 mL of any preferred beverage (such as soft drinks, milk, cordial, honey or fruit juice) and the mixture was heated briefly at moderate heat temperature while stirring until it becomes homogenous. It is suggested that the stirring and heating processes do not reach the boiling temperature.

2.2.3 Formation of juice pearl

Solution A (AlgiBath solution) was then poured into the provided container X, while container Y was filled with clean water as a cleaning solution. By using the provided syringe, the prepared solution B (CalciGum and preferred beverage solution) in the earlier process was dripped as droplets one by one onto the surface of solution A. The size of juice pearls can be altered by controlling the amount of solution B that is dripped into solution A. The pearls were left in solution A for 2 mins. The pearls were harvested by pouring solution A and the pearls from container X through a strainer into another container X. For the cleaning process, the collected pearls within the strainer were then soaked while lightly shaken in container Y for 15 s to prevent the clumping of pearls. The juice pearls can be kept in a container with the same solution B, kept refrigerated and can last for one week.

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2.4 Physical and chemical compositions of the pre-mixed powders and the juice pearls

The physical and chemical compositions of both AlgiBath and CalciGum powders were measured according to standard methods. Moisture was determined by the difference in weight after heating in a vacuum oven at 105°C until constant weight (AOAC, 1990). Protein and fat were determined according to in-house methods 0506 and 0511 respectively, based on Pearson's Chemical Analysis of Food (Harold, 1981). Carbohydrate was calculated according to in-house method 0512 based on the Method of Analysis for Nutritional Labelling (AOAC, 1993). The energy was determined according to AOAC standard method (AOAC, 1993) by calculating the amount of protein, fat and carbohydrate. Total sugar was determined by using high-performance liquid chromatography (HPLC). Calcium was analyzed by using the Varian Atomic Absorption spectrophotometer (Varian Techtron Analytical Methods for Flame Spectroscopy), whereas sodium was analyzed by using the Technicon Auto-analyzer II equipped with a flame photometer (Technicon Auto-analyzer II Industrial Method No. 240-72W).

In this study, the juice pearls produced by using a Juice Pearl Kit was containing stingless bee honey. The nutrient compositions of these stingless bee honey pearls were compared with commercial bee honey and stingless bee honey. Nutrient compositions namely energy, carbohydrate, protein, fat, dietary fibre, calcium, sodium, vitamin C and sucrose were measured according to AOAC standard methods and in-house methods, the same as mentioned earlier for the analysis of pre-mixed powders (AOAC 1993, Harold 1981).

3. Results and discussion

The main steps of spherification using the Juice Pearl Kit include solution preparation, pearl formation, harvest and storage. It involved making an AlgiBath solution by mixing AlgiBath powder with 400 mL water, followed by making a juice solution by mixing CalciGum powder with 140 – 150 mL of any preferred beverage. The juice solution was then dripped as droplets one by one onto the surface of the Algibath solution, by using the provided syringe to form juice pearls. The juice pearls were harvested by pouring all the AlgiBath solution together with the pearls from one container through a strainer into another container. The collected pearls within the strainer were then soaked for 15 secs in cleaning water to prevent the clumping of the pearls. The juice pearls can be served fresh or kept at a chill temperature for one week.

Every Juice Pearl Kit is suggested to contain six packets of each AlgiBath and CalciGum powder, which is estimated for 6 times usage. The amount of the packets can be varied, depending on the supplier. Also included in the Juice Pearl Kit is a syringe for dripping and forming the juice pearl, a measurement bottle for mixing the AlgiBath solution, a measuring cup for mixing the CalciGum with any beverages, forming trays, and a strainer for separating and collecting the juice pearls. Besides a complete Juice Pearl Kit, a supplier can produce a refill kit containing a few sets of AlgiBath and CalciGum powders for a consumer who's already bought the Juice Pearl Kit earlier.

Nutrient compositions of CalciGum and AlgiBath are shown in Table 1. The result showed that moisture content in CalciGum and AlgiBath pre-mixed powders was low with a value of 2.3 g/100 g (2.3%) and 4.7 g/100 g (4.7%), respectively. Low moisture content (less than 9%) is important in keeping the qualities of the powders for long storage duration. The moisture content of 9 and 10% showed no mold growth and no infestation, which is suitable for storage stability and longer shelf life of food products like powder and flour (Nasir *et al*, 2003). In every 100 g, CalciGum powder contains 380 Kcal energy, 0.2 g protein, 94.6 g carbohydrate, 86% of total sugar, 972 mg calcium, and 28.1 mg sodium, whereas AlgiBath powder contains 91.5 kcal energy, 0.2 g protein, 21.9 g carbohydrate, 60% of total sugar, 17.2 mg calcium and 4390 mg sodium. The usage of alginate salt as an ingredient in AlgiBath resulting a high detection of sodium with a value of 4390 mg. Analysis of fat showed both CalciGum and AlgiBath powders contain less than 0.1 g of fat in every 100 g.

Table 1. Nutrient compositions of CalciGum and AlgiBath premix powders

Nutrient composition (per 100 g)	CalciGum	AlgiBath
Energy (Kcal)	380±15.90	91.5±0.04
Protein (g)	0.2±0.01	0.2±0.01
Carbohydrate (g)	94.6±0.06	21.9±0.02
Fat (g)	< 0.1	< 0.1
Moisture (g)	2.3±0.02	4.7±0.01
Total sugar (g)	86.0±0.29	60.0±0.19
Calcium (mg)	972±4.53	17.2±0.43
Sodium (mg)	28.1±0.49	4390±45.9

Any liquid samples such as fruit juice, soda, tea, soft drinks, and even sauces and soups can be prepared for spherification by mixing a measured amount with CalciGum powder to make a smooth solution. The mixed solution is dripped one drop at a time into a bath solution made from AlgiBath powder (Figure 2). Calcium ions from the solution will react with the alginate ($NaC_6H_7O_6$) from the bath to form calcium alginate ($CaC_{12}H_{14}O_{12}$),

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which is a heat-stable gelatinous substance. Calcium acts as a bridge between the alginate chains, enhancing their interactions and favouring gelation (Halford, 2015). According to previous research by Sivakumaran and Prabodhani (2018), spherification is the shaping of a liquid into small edible spheres in calcium alginate capsules, in which the formed spheres have a liquid center and look like caviar. The chemical reaction of this process (reverse type of spherification) is shown in Figure 3. Making a juice pearl by using Juice Pearl Kit is an application of reverse spherification. The application of reverse spherification is wider as it can be used with nearly any type of liquid (Julia, 2021). By using this reverse spherification technique applied to Juice Pearl Kit, spheres like pearls with thin membranes out of liquids, were easily formed. The uniqueness of this juice pearl is the sensation when it gives a burst-in-the-mouth effect when it is consumed.

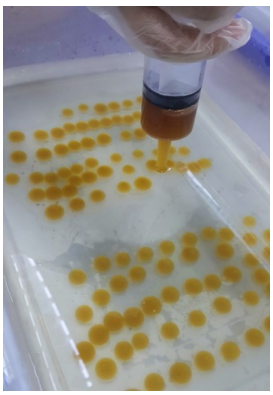

Figure 2. The making of juice pearls by dripping one drop of juice at one time into the AlgiBath solution

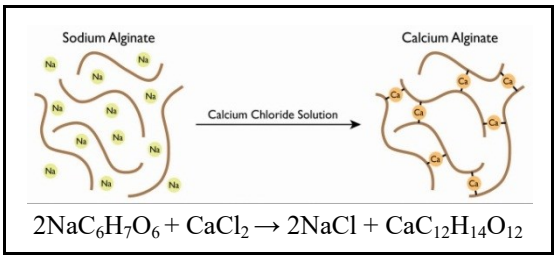

Figure 3. The chemical reaction of reverse spherification

Figure 4. Harvesting the pearls by pouring them into another container of bath solution through a strainer

Pearls can be harvested by pouring the pearls in bath solution through a strainer into another container. Pearls collected within the strainer are then lightly shaken in clean water to remove excess alginate residue on the juice pearl's surface (Figure 4). In the absence of alginate to react with calcium ions, the pearl's interior content will remain in liquid form. Once rinsed, the juice pearls can be stored in the original solution and kept in chilled conditions (Jyoti Sen, 2017).

Alginates are derived from marine brown algae classified as a hydrocolloid, which are large water-soluble molecules that enhance viscosity and are often used as texturizers. Alginates are unbranched copolymers of 1,4-linked-β-D-mannuronic acid and α-L-guluronic acid. In the absence of divalent ions (i.e., Ca^{2+}, Mg^{2+}), alginates only enhance viscosity. However, when in the presence of divalent ions, they form strong gels. The gel-forming properties of alginates are derived from their capacity to bind a large number of divalent ions. The gel strength is correlated with the proportion and length of the guluronic acid blocks in their polymeric chains (Vega and Castells, 2012). Juice pearls produced using this spherification kit are heat stable and show versatility in both iced and hot beverages. According to Sullivan (2019), once the pearl is formed, the structure of calcium-alginate is heat stable, which enables the pearl to be heated by steaming or adding to hot liquid.

Juice pearls can be enriched with different types of ingredients such as fruit juices and herbal extracts. This offers more options for customization and flavour pairings using local food ingredients. As an example, stingless bee honey-based juice pearls were produced by using a Juice Pearl Kit. These stingless bee honey pearls are suitable for direct consumption and can be used as a topping for desserts or culinary decoration. A high-value confectionery will give a new and healthier alternative for consumers and create potential new markets. Table 2 shows the nutrient content of the stingless bee honey pearls as compared to commercial stingless bee honey and commercial bee honey. The contents of carbohydrates, protein, fat and energy are not much different between stingless bee honey pearls and commercial honey. However, the amount of dietary fibre (1.3 g/100 g), calcium (189 mg/100 g) and vitamin C (22.9 mg/100 g) in stingless bee honey pearls were relatively high as compared to commercial honey. Commercial stingless bee honey contains less than 0.01 g/100 g dietary fibre, 19.1 mg/100 g calcium, and 15.1 mg/100 g vitamin C, whereas commercial bee honey contains less than 0.01 g/100 g dietary fibre, 6 mg/100 g calcium and 0.3 mg/100 g vitamin C. The use of alginate and calcium salt in the ready-to-use pre-mixed spherification powders in the Juice Pearl Kit has contributed to the increase of dietary fibre, calcium and vitamin C in the stingless bee honey pearls.

The result showed that the flavour, texture and

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nutrient compositions of the original stingless bee honey or any type of solution or beverage, can be easily enhanced or modified into a new food product. In wider application, Juice Pearl Kit is suitable for food and beverage entrepreneurs, bakeries, hawkers, food vendors, coffee shops, restaurants and fast-food centres, teachers and students for science projects, and everyone who wants to enjoy hours of culinary science fun.

Table 2. Nutrient compositions of juice pearls (containing stingless bee honey) as compared to commercial stingless bee honey and commercial bee honey

Nutrient composition (per 100 g)	Juice pearls (containing stingless bee honey)	Commercial stingless bee honey	Commercial bee honey
Energy (Kcal)	276	236	326
Carbohydrate (g)	67.4	58.4	86.1
Protein (g)	0.6	0.4	0.5
Fat (g)	0.1	< 0.01	0.3
Dietary fibre (g)	1.3	< 0.01	< 0.01
Calcium (mg)	189	19.1	6
Sodium (mg)	27.3	6.9	3.1
Vitamin C (mg)	22.9	15.1	0.3
Sucrose (g)	14.1	< 0.05	3.4

4. Conclusion

A starter kit to produce juice pearls from any type of liquid has been successfully developed, namely the Juice Pearl Kit. The concept of Juice Pearl Kit is by combining culinary, chemistry and fun, which offers an interesting and tasty exploration of food science. Juice Pearl Kit is using the reverse spherification technique because the application is wider as it can be used with nearly any type of liquid such as fruit juice, soda, tea, soft drinks, sauces or soups. The development of this easy-to-use kit will provide a new alternative for food processors to design locally flavoured juice pearls for a healthier bubble tea drink market. A similar kit with more advanced features, for example, a semi-automatic portable kit for making juice pearls is something potential to be developed in the future to meet the demand and the rapidly changed modern food culture.

Conflict of interest

The authors declare that there is no conflict of interest.

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