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Application of gelling agent in particle suspension beverage

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Abstract

It is often desirable to incorporate edible particles into beverages to increase their nutritional value and enhance their authenticity and visual appeal to customers. However, there is always a tendency for particles to either settle to the bottom, or float to the top of the beverage. In this project, a new formulation and processing technique have been created for making texture-enhanced particle suspension beverage (PSB). The desired properties of PSB are achieved by a combination of specific processing technique, specific amount of food gum as a gelling agent, citric acid and other food additives and a controlled processing temperature. The particles used can be pieces of fruits, grains, jelly cubes and other mixed inclusions. The developed beverage showed excellent suspension ability to levitate larger and denser dispersed particles (up to 0.6 g/particle) without significant effect on the organoleptic properties such as viscosity and mouthfeel taste of the original beverage. PSB shows a relatively low viscosity value of 6.12 ± 0.21 mPa·s, as compared to commercial cultured milk drink (15.64 ± 0.81 mPa·s), but slightly higher as compared to fruit juice drink (3.88 ± 0.81 mPa·s), carbonated drink (1.86 ± 0.94 mPa·s) and mineral water (0.91 ± 0.03 mPa·s).

Keywords: gelling agent, particle suspension beverage, levitate, viscosity

Introduction

Today's beverage market is becoming increasingly competitive as innovations continue to emerge to meet consumer demands. Manufacturers need to keep their drinks in line with market trends because hydration is no longer the main selling point for beverages. The challenge is not only to produce a drink with pleasant taste but also with health benefits and an attractive appearance. Innovative ingredients and solutions are emerging to help food technologists and manufacturers in adding flavours, colour and healthy ingredients as well as meet consumer demands for innovative beverages.

Visual appeal is important for beverages to look good and appealing. It is often desirable to incorporate edible particles into beverages to enhance the authentic and visual appeal to customers. The particles can be fruit pieces, finely ground herbs, seeds, grains, jelly cubes, beads and other mixed inclusions. This combination will also increase the nutritional values, enhance the desired mouthfeel taste and creates a chewing sensation while drinking.

It is advantageous if the added particles can remain homogeneously levitated throughout the beverage without having to stir or shake the container regularly. However, there is always a tendency for the particles to either settle at the bottom or float to the top of the beverage. The stable levitated food particles in the beverage is very important for marketing purposes and consumer acceptance of the product after it has been stored and displayed in the market for a certain duration.

The objective of this study is to apply gel-forming agent in the production of beverage solution that can homogeneously levitate various types of food particles within it, without making the solution too concentred or using density-based in formulation design to make the food particles levitate or suspend in the beverage. The viscosity of the beverage or solution created must be similar to other beverage products in the market like a carbonated drink, flavoured drink, or fruit juice, as the viscosity level and mouthfeel contribute to the organoleptic acceptance by the consumer. In addition to the ability to levitate the food particles, the beverage solution must be capable of holding the particles in place for a long period of product storage.

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Materials and methods

Processing of particle suspension beverage

The basic formulation of the aqueous phase of particle suspension beverage (PSB) was based on a mixture of water, sugar, food gum, sodium citrate, calcium lactate and citric acid. The food particles used in this study were prepared into various sizes ranging from 0.05 g up to 1.0 g, to determine the maximum weight of each food particle that could be levitated by the developed PSB solution.

To begin the process, food gum (gellan gum), sodium citrate and sugar were added and dissolved in the water while heating it at a moderate temperature of 40 – 50 °C. Calcium lactate was added to the solution and the heating process was continued until the temperature of the solution reaches 80 – 85 °C. The solution was allowed to cool, before adding the citric acid as a buffer for PSB. Sodium benzoate can be added at a concentration of 750 ppm/L as a preservative. The PSB solution was then poured into a beverage bottle, followed by adding in food particles (either fruit pieces, finely ground herbs, seeds, grains, jelly cubes, beads, granules or other mixed inclusions). The food particles were homogeneously levitated throughout the beverages by simply stirring or shaking the bottle, once.

The particle suspension beverage (PSB) was then pasteurised at 60 °C for 30 minutes. The method of producing particle suspension beverage is shown in *Figure 1*. PSB samples were stored under chilled condition before further analysis of proximate, viscosity and sensory tests. In addition, PSB samples were also stored at room temperature and refrigerated for storage studies.

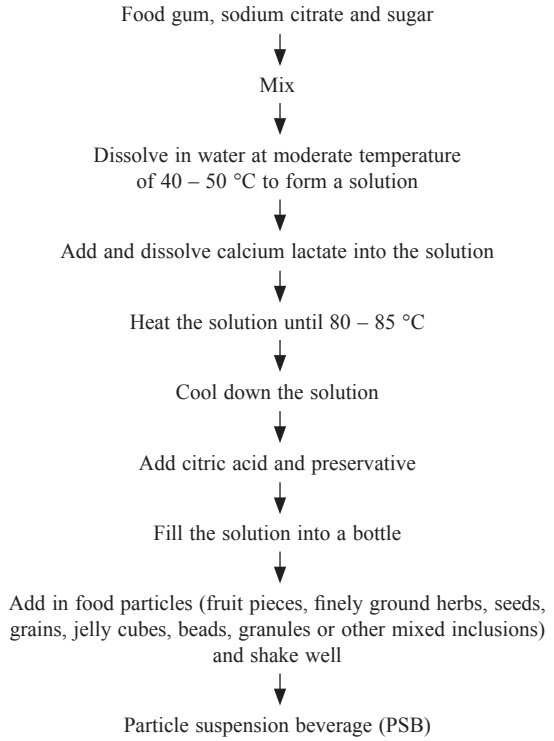

Figure 1. The processing technique of enhanced particle suspension beverage (PSB)

Viscosity analysis

The viscosity of the particle suspension beverage was measured and compared with various types of beverages available in the market, namely cultured milk drink, fruit juice drink, carbonated drink, grass jelly drink and mineral water. Viscosity analysis was performed on a Vibro Viscometer model SV-10 by A&D brand of Japan. The sample was added to a viscometer's cup and attached to the table along with the guide on the viscometer. The sensor unit was adjusted to make the sensor plate came into contact with the sample surface. Measurement was performed by the machine and the viscosity value of the sample was shown on the viscometer display screen.

Proximate analysis

The analysis of the particle suspension beverage was performed in duplicate. Moisture, ash and dietary fibre were determined by using standard AOAC methods (AOAC 1990 and 1993). Moisture was determined by the weight difference after being heated in a vacuum oven at 105 °C to a constant weight. Ash was determined by heating the sample in a furnace at 550 ºC to a constant weight to burn out all the carbon compounds, leaving them in the organic part (ash). Dietary fibre was determined as the resulting dry residue after treating a 2 g sample with 200 mL of 0.225 N sulphuric acid and with 100 mL of 2.5% sodium hydroxide solution. After filtering the digested material, it was washed with hot water and then ignited. By calculating the weight lost after ignition, the dietary fibre content was determined. Protein and fat were determined according to in-house method 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 Method of Analysis for Nutritional Labelling (AOAC 1993) by subtracting the values of moisture, protein, dietary fibre, fat and ash from 100. Energy was determined according to AOAC standard method (AOAC 1993) by calculating from the amount of protein, fat and carbohydrate.

Sensory acceptance

The tested sample was a particle suspension beverage (PSB) with honey beads as food particles levitated throughout the beverages. Twenty consumer respondents aged between 29 – 56 years were involved in this study. Prior to the test, respondents were briefed on sensory attributes with definitions and references when testing the sample of particle suspension beverage. The sample was rated based on the perceptual intensity of standard sensory attributes (colour, viscosity, aroma, taste and overall acceptance) by using 7 points Hedonic scale with 1 = disliked very much, 2 = disliked moderately, 3 = disliked slightly, 4 = neither liked nor disliked, 5 = liked slightly, 6 = liked moderately, and 7 = liked very much. Scores were collected and analysed statistically.

Data analysis

Statistical analysis was performed using SPSS. Data were statistically analysed by analysis of variance. The Duncan Multiple Range Test was used to detect the significance between the samples.

Results and discussion

Particle suspension beverage

The desired properties of particle suspension beverage (PSB) was achieved by a combination of specialised processing technique, the optimum amount of gelling agent (gellan gum) and food additives used and a controlled processing temperature. It was observed in this study that the most important step to produce perfect PSB was the use of 0.02% (w/v) food gum as a gel-forming agent (from total formulation) in the earlier mixing and heating process and the use of 0.2% citric acid as a buffer in the final step after the solution's temperature was slightly reduced to at least 50 °C. The initial mixture of food gum with any other food ingredient and additives should not be made too acidic or must be higher than pH 2.9 to ensure the food gum produces a network structure in a final product that can effectively levitate and suspend the added food particles. If beverage manufacturers intend to add an acidic ingredient in their PSB products to enhance certain flavours and functions, such ingredients must be added in the final stage of the process after the first solution containing food gum has been cooled to 50 °C. Adding acidic ingredient into the gel-forming solution at a temperature of more than 50 °C will interfere with the formation of a network structure that will reduce the ability or failure of the solution to levitate food particles.

Based on the ability of the solution to levitate the food particles, its low viscosity of the solution and the good sensory acceptance from the panellists, it is best to report that the optimised formulation for the accepted PSB is 0.02% food gum (gellan gum) as a gel-forming agent, 0.1% sodium citrate, 11% sugar, 0.07% calcium lactate, 0.2% citric acid and 88.61% water. The developed PSB was in clear true solution, apparently less concentrated with a relatively low viscosity like a fruit juice drink. Food particles added in the PSB can be seen to remain levitated homogeneously throughout the beverages without the need to stir or shake the bottle frequently. The food particles moved around when the bottle was shaken, but the end distribution still remained homogenous as before the bottle was shaken. It was also observed that turning the bottle did not move the food particles significantly. This was achieved when the gellan gum, a type of water-soluble polysaccharide was used as a gel-forming agent in the beverage mixture, with a specific procedure under not-too-acidic condition, which produced a fragile, mesh-like matric network inside the beverage that lightly holds the food particles in place (Anon 2004). Gellan gum is widely used in the food industry and in biotechnology as a gelling, texturing, stabilising, suspending and structuring agent. It forms a transparent gel that is resistant to heat and its gel strength is less dependent on pH than many other polysaccharides gels (Miyoshi and Nishinari, 1999). The gelation mechanism and solution-to-gel transition of gellan gum are influenced strongly by salts, polyols or sugars (Duran et al. 1994; Sanderson et al. 1988). Gellan gum can provide a wide range of gel textures with careful control of added salts, so these gels can provide the same texture as other polysaccharide gels or can create new textures.

According to Vilela et al. (2018), the suspension is a colloidal dispersion in which a solid (food particle) is dispersed in a continuous liquid phase, a solution of PSB. The beverage developed in this study showed excellent suspension ability to levitate larger and denser dispersed particles up to 0.6 g/particle (*Figure 2*). Previous research by Schramm (2005) has mentioned that suspended food particles are typically larger in size than 1000 nm with a diameter of more than 0.2 µm. The particle can be in any shape, preferably in form of spheres and should be visible to the naked eye (Schramm 2005).

There are many challenges associated with the development of particle suspension beverage without undesirable changes in their physical and sensory properties. One of the major concerns for suspension is to ensure that the internal phase is uniformly distributed and remains physically stable for a relatively long period of time during storage and consumption. Basically, particles can be kept suspended in a liquid by modifying the two main physical parameters of the aqueous phase of the beverage namely the density and viscosity.

The density of the beverage can be adjusted to equal or identical to the particle density to achieve gravitational balance. However, this method is complex and requires the addition of weighting agents or emulsifiers into the beverage. This method is also generally limited to suspending small and lightweight particles with sizes below one cubic millimetre. On the other hand, the viscosity of the beverage can be increased by using stabilising agents or hydrocolloids such as Arabic gum, xanthan gum, pectin, starch or carboxy methylcellulose. However, relatively large quantities of these additives may be required to achieve effective stabilisation and this will lead to an unpleasant mouth taste in the final product. In this study, as little as 0.02% of food gum

Figure 2. The PSB beverage can levitate up to 0.6 g food particle

was used because this amount suspended food particles successfully without giving any unpleasant mouth taste in the developed PSB drink. A small amount of food gum was used because this food gum is capable to increase the density and viscosity of the beverage, and can also prevent pulp sedimentation in fruit juices as reported by Bagheri et al. (2014).

The developed PSB is stable for storage at room temperature even after pasteurisation at 60 °C for 30 minutes. The network structure formed by the food gum suspends food particles effectively during pasteurisation and storage duration. It also prevents the formation of sediment which allows food particles to remain homogeneously levitated throughout the beverages.

Viscosity

The comparison of viscosity between the developed particle suspension beverage (PSB) and various beverage products is shown in *Table 1*. The result showed that the developed PSB has a relatively low viscosity value of 6.12 ± 0.21 mPa·s, as compared to cultured milk drink (15.64 ± 0.81 mPa·s), but slightly higher as compared to fruit juice drink (3.88 ± 0.81 mPa·s), carbonated drink (1.86 ± 0.94 mPa·s), grass jelly drink (1.59 ± 0.22 mPa·s) and mineral water (0.91 ± 0.03 mPa·s). The cultured milk drink used in this study as a comparison is a well-known product in the market, which indicates that the viscosity of the product is acceptable in terms of visual appearance and mouth taste. This suggests that the developed PSB, whose results showed significantly lower viscosity (6.12 ± 0.21 mPa·s) as compared to cultured milk drink (15.64 ± 0.81 mPa·s) should also have similar good acceptance from consumers. Besides, the viscosity of the PSB was not too much different as compared to the well-known brand of fruit juice drink (3.88 ± 0.81 mPa·s).

In the fruit juice industry, food gum is used as an efficient gelling agent and stabiliser that can increase the viscosity and density of beverages to suspend pulp particles in orange juice (Bagheri et al. 2014). The same application was applied in this study, where the appropriate amount of food gum was determined, and mixed with other food ingredients and additives using specific procedures to produce a perfect PSB drink in terms of suspension ability and acceptable viscosity.

Nutritional composition

Analysis of proximate and nutritional value of the developed particle suspension beverage (PSB) showed that it contains 51 kcal (213 kJ) of energy in every 100 ml, 12.5% carbohydrate and less than 0.1% of protein, fat and dietary fibre (*Table 2*). The moisture content of PSB is 87%, and the analysis also showed that the beverage contains 0.5% ash. The low content of protein, fat and dietary fibre in PSB solution (beverage) is also found in other beverages in the market such as carbonated drink and flavoured drink, and it is also consistent with an article reported by Lindsey et al. (2017) who mentioned the low nutrient content of beverage and packaged food in the United States. As this study focuses on the application and ability of gelling agent and food additive to levitate the food particles, the solution has been formulated as basic as possible to minimise the cost and the number of ingredients used, while leaving the work for a future food producer to add more ingredients of their preferences to enhance the value of their PSB product. Nevertheless, every food particle used (fruit pieces, herbs, seeds, grains, jelly, cubes, beads, granules) to levitate inside the PSB drink in this study, were nutritious and had health benefit.

Table 1. Comparison of viscosity of particle suspension beverage (PSB) and various types of beverage products.

	Sample					
	Cultured milk drink	Particle suspension beverage (PSB)	Fruit juice drink	Carbonated drink	Grass jelly drink	Mineral water
Viscosity	15.64 ± 0.81 a	6.12 ± 0.21 b	3.88 ± 0.81 c	1.86 ± 0.94 d	1.59 ± 0.22 d	0.91 ± 0.03 e

Mean values in the same row with different letters are significantly different at $p<0.05$

Table 2. Nutrient composition and proximate content of particle suspension beverage (PSB)

Proximate	Per 100 ml
Energy kcal (kJ)	51 kcal (213 kJ)
Protein (g)	< 0.1 g
Carbohydrate (g)	12.5 g
Fat (g)	< 0.1 g
Dietary fibre (g)	< 0.1 g
Ash (g)	0.5 g
Moisture (g)	87 g

Sensory acceptability of particle suspension beverage

The sensory scores provided by sensory respondents who assessed the quality of particle suspension beverage (PSB) containing honey (*Figure 3*) beads as food particles are shown in *Table 3*. Sensory evaluation was based on colour, viscosity, aroma, taste and overall acceptance using 7 points Hedonic scale where 1 represents "disliked very much" and 7 for "liked very much". It was observed that the score for every sensory attribute was greater than 5, indicating that the developed particle suspension beverage was preferred by the respondents. The highest score was for the attribute of taste with 5.80 ± 0.69, followed by overall acceptance with a score of 5.65 ± 0.67. This result was found to be almost similar to the findings by Joelia et al. (2007) who studies the sensory characteristics of cashew apple juice with respect to flavour and overall acceptability. A report by Joelia et al. (2007) also mentioned a good sensory score for the attribute of colour since the tasted product was having a natural colour from the apple. In this study, the PSB was developed as a basic solution with a basic sweetness of sugar, and with no additional colour added. The sensory score for PSB's colour was 5.35 ± 0.98 which was acceptable. Future potential food producers should consider the use of additional flavour and appropriate colour to suit their products.

Besides, the sensory score for PSB's viscosity was 5.40 ± 1.04, while 5.05 ± 0.82 for the aroma. None of the attributes for this PSB scored below the mean score (3.5) of the maximum score (7) of the scale. Random comments by the respondents have stated that the beverage texture and the food particles inside the PSB did not significantly affect the organoleptic properties (viscosity and mouth taste) of the original beverage. Besides, respondents also commented that the added food particles in the beverage gave some sensory sensation and they enjoyed it. A similar result was also reported by Masooma et al. (2017) when respondents gave a good sensory score for the attribute of swollen basil seeds in the developed beverages.

Figure 3. The PSB beverage containing honey beads as food particles

Product potential

The particle suspension beverage (PSB) provides an alternative to the local beverage industries to create new potential markets, as well as to support the implementation of policies in several countries to reduce the use of plastic straws. Most of the current beverage products in the market for example the grass jelly drink and bubble milk tea with tapioca balls, require the use of a plastic straw to sip and enjoy the food particles at the bottom of the beverage. Unlike PSB, the food particles are levitated throughout the beverage making it easier for a consumer to continue drinking it from the bottle or cup. Besides, the homogenously suspended food particle in PSB gives a unique and attractive appearance to the beverage.

Conclusion

The beverage industry provides an incredible platform for innovation as it is a great opportunity for creating interesting product concepts and delivering functional ingredients. The application of gelling agent (gellan gum) in particle suspension beverage (PSB) showed excellent suspension ability to levitate larger and denser dispersed food particles (up to 0.6 g/particle) without a noticeable effect on the organoleptic properties such as viscosity and mouth taste. The production of perfect PSB can be achieved by a combination of specific processing techniques, an optimal amount of gelling agent and food additives and a controlled processing temperature.

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Table 3. Sensory score by respondents on various attributes of particle suspension beverage (PSB) containing honey beads as food particles

	Colour	Viscosity	Aroma	Taste	Overall acceptance
Particle suspension beverage	5.35 ± 0.98	5.40 ± 1.04	5.05 ± 0.82	5.80 ± 0.69	5.65 ± 0.67

Sensory score: 7 = liked very much, 6 = liked moderately, 5 = liked slightly, 4 = neither liked nor disliked, 3 = disliked slightly, 2 = disliked moderately, 1 = disliked very much

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