

Physical, chemical and quality properties of starfruit juice, agglomerate and drink

(Ciri fizikal, kimia dan kualiti jus, aglomerat dan minuman belimbing)

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Key words: starfruit, juice, agglomerate, physical, chemical and microbiological properties

Abstract

Starfruit juice can be converted into powder or agglomerate by the process of fluidized bed drying and agglomeration. One kilogramme of ground sugar was used as a carrier for the fluidized bed drying agglomeration process. Essential minor additives i.e. anhydrous citric acid, starfruit flavour and permitted food colour were used to boost up flavour, sugar-acid balance and eye appeal of the product. Suitable process variables used were 40 °C as the process temperature, 20 m³/h as the volumetric airflow rate which resulted in an air velocity of 1.5 m/s, an atomization pressure of 3 bar and a pump flow rate of 8 g/min. Fresh starfruit juice was used as a binder for the agglomeration process in the fluidized bed dryer which was sprayed at the beginning of the drying process.

The juice recovery was 65.07%, the moisture content of the fruit was 90.12% and the colour values were $L^* = 6.31$, $a^* = -0.22$, $b^* = 8.76$. The total titratable acidity (TTA) of the juice was 0.25%, the pH was 3.52, the total soluble solid (TSS) was 8.0 and the viscosity was 3.0 cP. The bulk density of the agglomerate was 0.63 g/ml, the moisture content ranged from 1.63–1.68% for the storage period of 0–12 months. As the storage time progressed, the colour changed from light yellow to a darker dull yellow. The particle size distribution of the starfruit agglomerate showed that a higher percentage of the particles were retained on the larger meshes. From the cumulative distribution plot, the median diameter for the carrier and agglomerate obtained was 350 µm and 500 µm respectively. The critical moisture content of the agglomerate was 6.0% and the equilibrium relative humidity was 58.5%.

Organoleptic evaluation of starfruit drink compared to the juice for the whole storage period was based on five sensory attributes. The nutrient compositions of the agglomerate at zero month of storage did not differ much from the 12th month of storage. Microbiological quality remained the same throughout the 12 months of storage. This indicated laminated OPP/PE/AL/PP (with thickness 20 µ:15 µ:7 µ:25 µ) was suitable to be used for the storage of the starfruit agglomerate for 12 months at room temperature.

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Introduction

Beverage products cover alcoholic beverages, hot beverages, soft drinks and juices. All beverages perform an essential nutritional function – that of hydration as well as giving enjoyment to the consumer (Ashurst 2001). Several considerations are critical in formulating beverages i.e. the ingredient selection, the type of processing needed and the desired product specifications. Beverage creation is based on concept definition, ingredient selection, formula testing and processing which leads to quality and stable shelf life (Saunders 1994).

Besides fresh fruit beverages, there is an untapped market for ready-to-drink fruit beverage powder. This ready-to-drink fruit beverage powder can be processed using the fluidized bed dryer and agglomerator, which primarily mixes and dries both the powder and liquid ingredients in the mixing chamber to obtain a homogeneous mixture with liquid evenly distributed throughout the powder (Anon. 1981). The fluidized bed offers the advantages of simplicity of design, intimate gas-to-particle contact, and uniform particle exposure without mechanical agitation (Brown et al. 1972). The objective of agglomeration is to get powdered ingredients to adhere together to form larger particles in order to achieve improved physical characteristics such as flowability and dispersibility (Duxbury 1988). Besides the physical characteristics, a beverage powder or a powdered soft drink requires developing a blend of compatible ingredients that will not react in the package or have inherent stability problems (Burg 1998).

Therefore, the physical, chemical, quality characteristics based on nutrient analysis and microbiological quality and the choice of packaging material are important criteria to be considered for developing a successful beverage powder. There is very little information on the ready-to-drink fruit beverages using the fluidized bed drying process. This study was undertaken to

produce a ready-to-drink fruit beverage powder from starfruit and to study its physical, chemical and quality properties.

Materials and methods

Fruit

Averrhoa carambola (L) variety, B10 with colour index 5 (Anon. 2003) was purchased locally from a market and stored at ambient temperature for 24 h before processing. The fruit was sliced manually and crushed in a high output centrifugal juice extractor (Santos N°28, France). The extracted juice was strained using a muslin cloth to remove traces of fibre.

Carrier

Granulated sugar was purchased from local market. The sugar was ground using the disk mill (Safe World Enterprise, Model SWE-UM 50-SS, Malaysia). Particle size distribution of the ground sugar was carried out by using the American Society of Testing and Materials (ASTM) mesh no. 20, 30, 40, 45, 50 and 60 on a Rotap device (Endecott Test Sieve Shaker, England) for 5 min. One kilogramme of this ground sugar with mean particle size of 425 μ was used as a carrier in the fluidized bed dryer and agglomerator.

Minor additives and binder

The minor additives used in this study were starfruit flavour, anhydrous citric acid and permitted food colour (Lee 2001). One per cent of starfruit flavour (Bayer Malaysia Sdn. Bhd.) based on 1 kg of sugar was used. A solution weight of 2 g (from 1% stock solution) of tartrazine (Boustead Engineering Sdn. Bhd. Malaysia) was adequate for the product. Three per cent of anhydrous citric acid based on 1 kg of sugar (Shin Heng Chemicals Sdn. Bhd. Malaysia) was mixed thoroughly with the carrier. It was found that this amount of citric acid produced a suitable sugar-acid level for this product. The starfruit flavour and food colour, which were used as a binder, were added to 40 g of fresh starfruit juice for the

agglomeration process in the fluidized bed dryer. The binder was sprayed onto the carrier in the fluidized bed dryer at the beginning of the drying process to ensure all the minor additives were evenly distributed on the carrier. This was immediately followed by spraying of fresh starfruit juice.

Fluidized bed dryer and agglomerator

The fluidized bed dryer and agglomerator (Glatt model GPCGI, Germany) was used in this study.

Process parameter

The process parameters were determined after several trials. They were found to produce reproducible results. The spraying process was carried out by an atomized sprayer consisting of a nozzle of 1.0 mm diameter. The bed load used was 1 kg of carrier. The inlet temperature used was 70 °C and the process temperature was 40 °C in the drying chamber. The fluidizing airflow rate was 20 m³/h which resulted in an air velocity of 1.5 m/s. The atomization pressure at the spray nozzle was 3 bar. The flow rate of the peristaltic pump used was 8 g/min. The total drying and agglomeration duration was 3 h. The amount of starfruit juice sprayed during the drying and agglomeration process was 1 kg.

Production of agglomerate, packaging and storage studies

The process parameters of the fluidized bed dryer and agglomerator were set before loading. Preheating of the drying chamber was carried out for 15 min on empty load until equilibrium had been attained which was indicated by stable inlet, product and drying temperatures. One kilogramme of ground sugar was used as the carrier and loaded into the product container. After loading, heating was continued for another 15 min to ensure the carrier was thoroughly heated or until equilibrium had been attained. The shaking device was activated at 10 interval for a duration of 5 s to prevent product from sticking to the filters.

When the operating condition were at equilibrium, spraying of the binder (to which minor additives were added) commenced at the beginning of the agglomeration process to ensure uniform blending of the ingredients (Lee 2000). This was immediately followed by spraying of fresh starfruit juice. The spraying of fresh starfruit juice continued for 3 h until the product was well agglomerated and fluidized by the air velocity. After spraying was terminated, drying continued for another 30 min to ensure the starfruit agglomerate was thoroughly dried. At the end of the process, the product was unloaded from the product container and was cooled for 2 h at room temperature (*Figure 1*).

The product was packed in unprinted bags of laminated OPP/PE/AL/PP (with thickness 20 μ :15 μ :7 μ :25 μ) with dimensions 10 cm x 13 cm containing 50 g each and heat-sealed. Prior to storage, 20 bags were randomly taken of which nine bags were for physical-chemical properties and nutrient analysis, five bags for sorption isotherm, four bags for organoleptic evaluation and two bags for microbiological evaluation at zero-month storage. The remainder of the packs were stored at ambient temperature for one year. At the

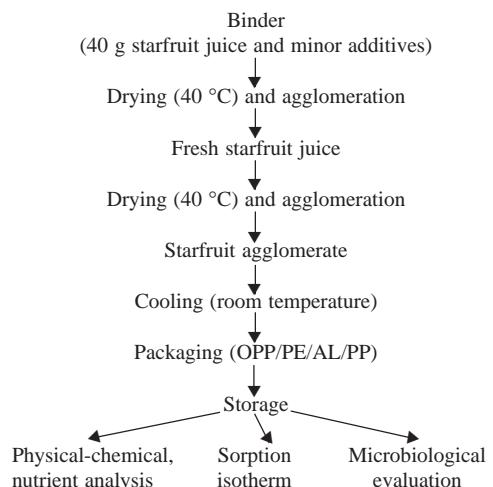


Figure 1. Production, packaging and storage studies of starfruit agglomerate

fourth month of storage, eight bags were randomly taken of which two bags were for physical-chemical properties, four bags for organoleptic evaluation and two bags for microbiological evaluations. The same process was carried out at the eighth month of storage. At the 12th month of storage, 15 bags were randomly taken of which nine bags were for physical-chemical properties and nutrient analysis, four bags for organoleptic evaluation and two bags for microbiological evaluations.

Physical-chemical properties of fruit and its juice

A total of 20 colour readings of the fruit skin were randomly taken from five fruits using a chroma meter (Minolta Camera Co. Ltd., model CR-200, Japan) for L^* , a^* , b^* values. Triplicate readings of the moisture content (wet basis) of the macerated starfruit fruit were determined by using the AOAC Official Methods (AOAC 1990). The juice recovery was determined from triplicate samples obtained at different batches of processing by subtracting the weight of extracted juice from the weight of the fruit.

The juice pH was determined using the WTW pH meter (Werkstätten, Germany). Total soluble solid (TSS) of the juice was determined using the refractometer (Atago NI, range 0–32%, Japan). The juice viscosity was determined using the viscotester (Haake – Type VT01, Germany) using spindle no. 4 at ambient temperature. Total titratable acidity (TTA) of the juice was determined by titrating a known weight of juice to pH 8.1 with 0.1 N NaOH and the results expressed as a percentage of oxalic acid (AOAC 1990). Triplicate readings of the juice colour were determined for L^* , a^* , b^* values.

Physical-chemical properties and nutrient analysis of agglomerate

The starfruit agglomerate was sieved through ASTM mesh no. 20, 30, 40, 45, 50 and 60 on a Totap device to determine the particle size distribution. Three colour

readings of the starfruit agglomerate was determined for L^* , a^* , b^* values. Triplicate readings of the moisture content (wet basis) of the agglomerate were determined by using the AOAC Official Methods (AOAC 1990). Triplicate readings of bulk density of the agglomerate were determined (Kim and Toledo 1987). This was measured as the weight of the agglomerate per unit volume of the graduated cylinder, which contained the agglomerate. Nutrient analysis of the starfruit agglomerate was carried out for zero and 12 months of storage by using the AOAC Official Methods (AOAC 1990). The nutrient analysis carried out were protein, fat, ash, crude fibre, total sugars, energy, dietary fibre, calcium, iron, sodium, potassium, vitamin C and A.

Sorption isotherm

Sorption isotherm of the product at the beginning of the storage period was analysed according to the method of Labuza (1984). It is the relationship between the moisture content of a product and the relative humidity at which it is in equilibrium at the temperature (Heiss 1970). A known weight of the product was placed in a desiccator, which was exposed to different saturated salt solutions of known relative humidity. The initial moisture content of the product was determined according to the AOAC Official Methods (AOAC 1990) and the initial water activity value was determined by,

$$a_w = \frac{\% \text{ ERH}}{100}$$

where a_w = water activity

ERH = equilibrium relative humidity

The moisture content of the product at different relative humidity was determined as physical changes of the product were observed. Sorption isotherm curve was obtained by plotting the moisture content on the Y-axis versus equilibrium relative humidity on the X-axis. Each sample was

indicated by a point on the plot and a smooth curve was generated through the data.

Physical-chemical properties and organoleptic evaluation of starfruit drink

Starfruit drink was obtained by dispersing 100 g of agglomerate in 1 litre water at 5–15 °C and stirring for about 1 min (Gillies 1973). L^* , a^* , b^* values, TTA, pH, TSS and viscosity in triplicate readings were determined from the starfruit drink. Organoleptic evaluation of the starfruit drink compared to the fresh starfruit juice was carried out. A total of 20 experienced panellists were asked to rate the flavour, sweetness, sourness, colour and overall acceptability using a 9-point hedonic scale where 1 = dislike extremely and 9 = like extremely.

Microbiological evaluation

Plate count of total viable count (TVC), yeast and mould (Y&M) and coliform count was done on all samples in triplicates using pour plate method of ICMSF (1978). Plate count agar (Oxoid, Hampshire England), malt extract agar (Oxoid) and Mac Conkey broth (Oxoid) media were used to enumerate TVC, Y&M and coliform accordingly. A 10 g of each sample replicate was weighed and then homogenised in a quarter strength Ringer buffer solution (Oxoid, Hampshire England) using laboratory blender (Stomacher 400, Seward England). Homogenate was then diluted decimally following which 1 ml of the selected diluted homogenate was pipetted into an empty petridish and then appropriate molten agar was then poured and mixed. For coliform count, the most probable number (MPN) method was used. The Y&M plates were incubated at 32 °C for 72 h while the TVC plates and MPN tubes were incubated at 37 °C for 48 h. Viable counts of TVC and Y&M were determined by counting the number of colonies formed and reported as colony forming units per gramme (cfu/g).

Water activity values of the starfruit agglomerate were determined using water activity meter (AQUA Lab Model 3rE, USA).

Results and discussion

Physical-chemical properties of fruit and its juice

Juice recovery was moderately low at 65.07% and the moisture content of the fruit was 90.12% which is consistent with the results shown by Shaw et al. (1998). The juice obtained was pale yellow with colour values $L^* = 6.31$, $a^* = -0.22$, $b^* = 8.76$ (Table 1). The TTA level was low at 0.25%, the pH value was 3.52, it had moderately low TSS at 8.0 and the juice can be considered as a non-viscous fluid at 3.0 cP.

Physical-chemical properties of starfruit agglomerate

The bulk density of the starfruit agglomerate was 0.63 g/ml which falls under the category of food powders which have densities in the range of 0.3–0.8 g/ml (Peleg and Bagley 1983). The moisture content of the starfruit agglomerate ranged from 1.63–1.68% (Table 2) for the storage period of 0–12 months. This value is lower than the value that Heiss (1970) reported for safe storage where the moisture content of 2% is required for fruit juice powder such as pineapple and grapefruit juice powder.

At the beginning of the storage period, the colour of the starfruit agglomerate was light yellow with the colour values

Table 1. Mean values[†] of colour, TTA, pH, TSS and viscosity of starfruit juice

Characteristic	Juice
Colour	
L^*	6.31 ± 0.25
a^*	-0.22 ± 0.02
b^*	8.76 ± 0.14
Total titratable acidity (%)	0.25 ± 0.08
pH	3.25 ± 0.1
Total soluble solids	8.0 ± 0.37
Viscosity at 30 °C(cP)	3.0 ± 0.16

[†]Average from three batches of processing

Table 2. Mean value⁺ of colour and moisture content of starfruit agglomerate during 12 months storage

Storage period (month)	Colour			Moisture content
	L*	a*	b*	
0	92.93 ± 0.17a	-6.21 ± 0.06a	25.95 ± 0.18a	1.64 ± 0.018a
4	79.95 ± 0.18b	0.63 ± 0.03d	23.30 ± 0.17b	1.68 ± 0.013a
8	78.79 ± 0.17c	1.22 ± 0.01c	22.33 ± 0.18c	1.63 ± 0.012a
12	73.64 ± 0.38d	2.47 ± 0.01b	24.36 ± 0.19a	1.66 ± 0.011a

⁺Average from two bags of 50 g each

Mean value with different letters in each column are significantly different ($p < 0.05$) based on t-test

Table 3. Partical size distribution of starfruit agglomerate* and carrier**

Mesh no.	Size (mm)	% retained	
		Carrier	Agglomerate
20	850	10.29 ± 4.23	14.20 ± 3.59
30	600	8.55 ± 2.76	22.71 ± 4.78
40	425	12.30 ± 3.65	31.39 ± 5.21
45	355	13.86 ± 4.41	18.35 ± 2.34
50	300	13.06 ± 6.12	6.32 ± 2.14
60	250	16.91 ± 4.85	0.78 ± 1.48
Pan	-	25.03 ± 5.22	6.26 ± 3.01

*Average of six batches from 0 month storage period

**Average of three batches

$L^* = 92.93$, $a^* = -6.21$, $b^* = 25.95$ (Table 2). As the storage time progressed, the colour of the agglomerate changed from light yellow to a darker dull yellow which was indicated by the overall L^* , a^* and b^* values. L^* represents the lightness of colours from 0–100, being small for dark colours and large for light colours (Dussi et al. 1995). The L^* value decreased significantly from 0–12 months of storage. At zero month storage, the a^* value was negative indicating green colour and it changed significantly to an increasing positive value indicating red colour from the fourth month onwards. The b^* value is positive for yellow. At the beginning of the storage period, the b^* value was significantly different from the fourth and eighth month but was not significantly different from the 12th month.

Particle size distribution of carrier and starfruit agglomerate

The purpose of particle size distribution is to determine the percentage frequency of distribution of particle sizes (Lachman et al. 1986). Particle size distribution of the carrier showed that between 8–16% (Table 3) of the particles were retained on all the meshes and about 25% were retained on the pan indicating that 25% of the particle size was smaller than 250 μm .

As compared to the carrier, the particle size distribution of the starfruit agglomerate showed that a higher percentage of the particles were retained on the larger meshes and less than 10% of the particles were retained on the smaller meshes. This occurrence happened as a result of agglomeration, whereby several particles are caused to adhere to each other in random fashion, resulting in a porous, open structure aggregate of greater size than the original individual particle (Pintauro 1972). The overall particle size distribution of the agglomerate and the carrier can be depicted clearly in the cumulative distribution plot (Figure 2) which shows how much material lies above or below a particular size (Washington 1992).

As was discussed earlier, the plots show that for a particular mesh size, the carrier has more percentage passed as compared to the agglomerate. It can also be seen that the carrier plot is more linear as compared to the agglomerate plot indicating that almost equal amount of particles have

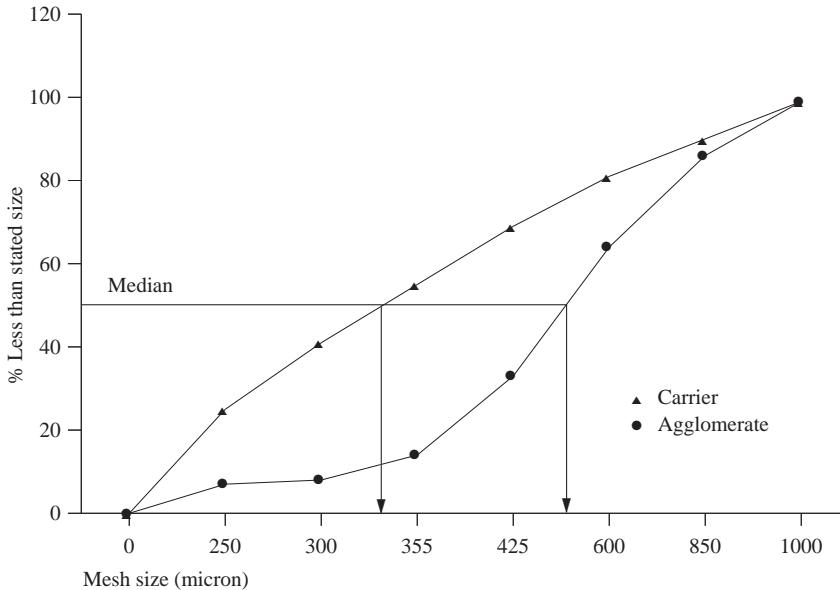


Figure 2. Cumulative distribution plot of starfruit agglomerate and carrier

the same percentages, on the y-axis. The median diameter for which 50% of the particles measured are less than the stated size (Lachman et al. 1986). In this figure, the median diameter for the carrier is 350 μm and the median diameter for the agglomerate is 500 μm , indicating that the median diameter of the agglomerate is bigger than the carrier. This is reasonable since agglomeration caused the particle to be larger.

Sorption isotherm of starfruit agglomerate

The initial moisture content of the starfruit agglomerate was 2.52% and the water activity was 0.33. The critical moisture content of the starfruit agglomerate was 6.0% and the equilibrium relative humidity was 58.5% (Figure 3). At this point, the product was damp and clumping occurred.

Physical-chemical properties of starfruit drink

At zero month, the starfruit drink was light in colour which was represented by L^* value (Table 4). The L^* value decreased significantly from 0 to 4, 8 and 12 months of storage indicating that the colour changed

from light to darker colour. The a^* value was negative indicating that the colour was green and it changed to a positive value at 4, 8 and 12 months of storage. The a^* value was significantly different from each other during the 4 months of storage. Similarly, the b^* value was significantly different from each other during the 4 months of storage.

The TTA of the starfruit drink was significantly (Table 4) different from each other during the 12 months of storage. However, the difference of this value was small which ranged from 0.21–0.27% and was close to the TTA of the starfruit juice which was 0.25% (Table 1).

The TSS of the drink was 9.0 (Table 4) for the 12 months of storage and it was slightly higher than the TSS of the starfruit juice which was at 8.0 (Table 1). The viscosity of the drink was significantly not different during the 12 months of storage (Table 4). This value ranged from 0.26–0.27 cP and was very similar to the viscosity of the juice which was 3.0 cP (Table 1).

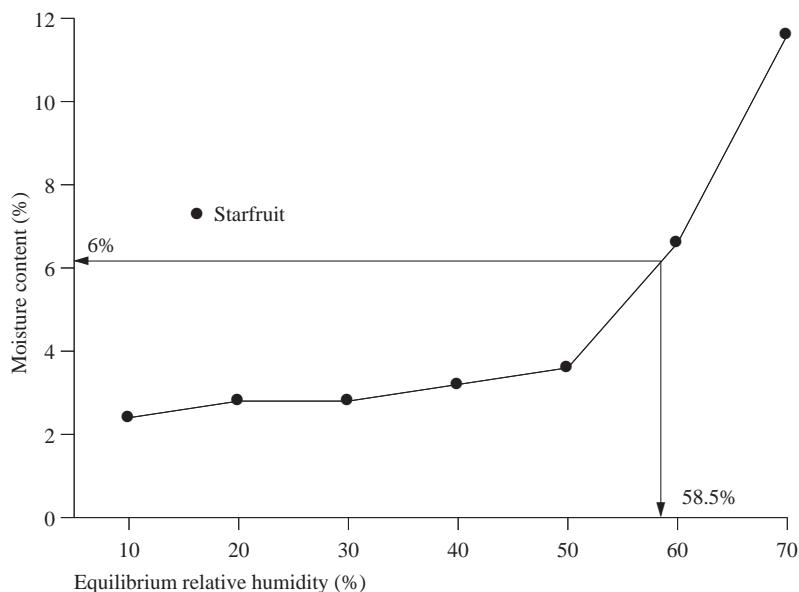


Figure 3. Sorption isotherm of starfruit agglomerate

Table 4. Mean values⁺ of colour, TTA, pH, TSS and viscosity of starfruit drink during 12 months of storage

Storage period (month)	Colour			TTA (%)	pH	TSS	Viscosity at 30 °C (cP)
	L*	a*	b*				
0	77.30 ± 0.15a	-6.60 ± 0.001a	23.14d	0.21d	2.99a	9.0a	0.28a
4	58.20 ± 2.63b	3.15 ± 0.02d	30.37c	0.31b	3.04a	9.0a	0.26a
8	60.50 ± 0.21b	3.75 ± 0.001c	33.14b	0.35a	2.95a	9.0a	0.28a
12	61.48 ± 0.05b	4.27 ± 0.006b	34.76a	0.27c	3.05a	9.0a	0.27a

⁺Average from four bags of 50 g each

Organoleptic evaluation of starfruit drink

At 0 month, the colour of the starfruit drink was not significantly different from the juice (Table 5) with a higher score given to the drink. However, at the 4th, 8th and 12th month, the starfruit drink was significantly different ($p < 0.01$) from the juice with a higher score given to the juice. This was consistent with the L* value of the drink (Table 4) which decreased significantly from 0 to 4, 8 and 12 months of storage indicating that the colour changed from light to a darker colour.

The flavour of the starfruit drink was not significantly different from the juice (Table 5) throughout the 12 months of storage. The sweetness of the starfruit drink

was significantly different from the juice during 0 month of storage. However, for the 4th, 8th, and 12th month of storage, the sweetness of the starfruit drink was not significantly different from the juice. However, a higher score was given to the drink. The sourness of the starfruit drink was not significantly different from the juice throughout the 12 months of storage. Similarly, the overall acceptability of the starfruit drink was significantly not different from the juice throughout the 12 months of storage.

Nutrient analysis of agglomerate

The nutrient analysis (Table 6) of the starfruit agglomerate showed that most of

Table 6. Mean values⁺ of nutrient analysis of starfruit agglomerate stored at 0 and 12th month

Chemical analysis	Composition in 100 g	
	Agglomerate at 0 month	Agglomerate at 12th month
Protein (N x 6.25) (g)	0.8	0.2
Fat (g)	0.1	0
Ash (g)	0.1	0.1
Crude fibre (g)	0.6	0.6
Total sugars (g)	93.7	93
Total carbohydrate (g)	96.6	97.1
Dietary fibre (g)	Nil	Nil
Moisture (%)	1.8	2
Energy (Kcal)	391	392
Calcium (mg)	1	1
Iron (mg)	0.6	0.5
Sodium (mg)	1	1
Potassium (mg)	59	63
Vitamin C (mg)	3.9	3.8
Vitamin A (µg)	6	2.4

⁺Average of two analyses

Table 5. Average scores⁺ for five sensory attributes of starfruit drink and juice

Storage period (month)	Sample	Colour	Flavour	Sweetness	Sourness	Overall acceptability
0	Drink	6.45a	5.45a	6.20a	5.60a	5.75a
	Juice	5.90a	5.95a	5.10a	5.65a	5.35a
4	Drink	5.55a*	5.55a	5.80a	5.50a	5.50a
	Juice	6.65b*	5.10a	5.40a	4.53a	4.63a
8	Drink	5.45a*	5.53a	5.83a	5.20a	5.38a
	Juice	7.00b*	6.03a	4.95a	5.35a	5.50a
12	Drink	5.38a*	5.48a	5.90a	5.70a	5.68a
	Juice	6.55b*	6.10a	5.11a	5.40a	5.80a

Mean values with different letters in each column are significantly different ($p < 0.05$) based on t-test

*Mean values with different letters in each column are significantly different ($p < 0.01$) based on t-test

⁺Using a 9-point hedonic scale where 1 = dislike extremely and 9 = like extremely

the compositions were relatively low except for the total sugars, total carbohydrate and energy value. This was reasonable because sugar was used as a carrier. Potassium value was relatively high. The nutrient composition of the agglomerate at 0 month of storage did not differ much from 12th month of storage indicating that laminated OPP/PE/AL/PP (with thickness 20 µ:15 µ:7 µ:25 µ) was suitable to be used for the storage of the starfruit agglomerate for 12 months at room temperature.

Microbiological quality

Microbiological quality (Table 7) of the starfruit agglomerate remained almost the same throughout the 12 months of storage period. In fact the TVC and Y&M became less after 4 months of storage. The a_w value increased from 0.25 at 0 month to 0.45 at the end of the storage period indicating a slight moisture ingress which was not detrimental. A_w is a value which indicates the free available water in the starfruit agglomerate that will allow microorganisms

Table 7. Microbiological quality* of starfruit agglomerate stored for 12 months

	0	4	8	12
Total viable count (cfu/g)	3.7 x 10 ²	1.4 x 10 ²	6.5 x 10	3.0 x 10
Yeast & mould (cfu/g)	2.0 x 10 ²	3.0 x 10	1.0 x 10	1.0 x 0
Coliform (MPG/g)	0	0	0	0
Water activity value (a _w)	0.25	0.41	0.43	0.45

*Average of two analyses

to grow. Eventhough the a_w increased during storage, 0.45 was still very low to allow any growth to take place. Therefore, the product was very stable from microbial spoilage.

Conclusion

Starfruit agglomerate produced by fluidized bed drying and agglomeration process using ground sugar as a carrier produced a ready-to-drink fruit beverage with acceptable properties. Suitable process variables were used during fluidized bed drying and agglomeration. The starfruit juice played a major role as a binder for successful agglomeration which produced a range of suitable particle size distribution. The physical and chemical properties of the starfruit drink depended upon several chemical attributes of the product, namely colour, flavour, TTA, pH and TSS which were contributed by the starfruit juice as well as the essential minor additives. Storage of starfruit agglomerate for 12 months at room temperature using laminated OPP/PE/AL/PP (with thickness 20 µ:15 µ:7 µ:25 µ) pouches did not change the physical, chemical and quality properties of the agglomerate. The only property that changed between the 0 month and 12 months was the L* value, which was not critical, since this value indicated that the lightness of the agglomerate changed to a darker colour.

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Abstrak

Jus belimbing boleh diubah menjadi serbuk atau aglomerat melalui proses pengeringan pembendaliran hampan dan pengaglomerisasi. Satu kilogram gula kasar digunakan sebagai pembawa bagi proses pengeringan pembendaliran hampan dan pengaglomerisasi. Aditif penting dalam jumlah sedikit iaitu asid sitrik kontang, perisa belimbing dan pewarna makanan dibenarkan untuk digunakan bagi meningkatkan rasa,imbangan gula-asid dan rupa hasilan. Pembolehkan proses yang sesuai digunakan ialah suhu pemprosesan 40 °C, kadar aliran isian udara 20 m³/jam yang menghasilkan halaju udara 1.5 m/saat, tekanan pengabusan 3 bar dan kadar aliran pam 8 g/min. Jus belimbing segar digunakan sebagai pengikat dalam proses aglomerisasi dalam pengeringan pembendaliran hampan yang disembur pada awal proses pengeringan.

Kadar pulangan jus ialah 65.07%, kandungan lembapan buah 90.12% dan nilai warna ialah $L^* = 6.31$, $a^* = -0.22$, $b^* = 8.76$. Jumlah asid tertitrat jus (TTA) ialah 0.25%, pH 3.52, jumlah pepejal larut (TSS) ialah 8.0 dan kelikatan ialah 3.0 cP. Ketumpatan pukal aglomerat ialah 0.53 g/ml, kandungan lembapan antara 1.63–1.68% bagi tempoh penyimpanan dari awal hingga 12 bulan. Apabila tempoh penyimpanan bertambah, warna berubah daripada kuning cerah menjadi kuning gelap dan kusam. Taburan saiz partikel aglomerat belimbing menunjukkan peratusan lebih tinggi partikel tertahan di atas jaringan yang lebih besar. Daripada plot taburan terkumpul, didapati garis pusat tengah pembawa ialah 350 μm manakala aglomerat ialah 500 μm . Kandungan lembapan yang kritikal bagi aglomerat ialah 6.0% dan kelembapan bandingan seimbang ialah 58.5%.

Penilaian rasa berdasarkan lima ciri deria rasa sepanjang tempoh penyimpanan dibuat dengan membandingkan minuman belimbing dan jus. Komposisi zat makanan di dalam aglomerat tidak banyak berbeza selepas disimpan selama 12 bulan. Analisis mikrobiologi juga menunjukkan tiada pertumbuhan mikroorganisma diuji. Ini menunjukkan pembungkus OPP/PE/AL/PP (dengan ketebalan 20 μm :15 μm :7 μm :25 μm) berlaminat sesuai digunakan untuk penyimpanan aglomerat belimbing selama 12 bulan pada suhu bilik.