

Physical and chemical properties of pineapple juice, agglomerate and drink

(Ciri fizikal dan kimia jus nanas, aglomerat dan minuman nanas)

S.Y. Lee*

Key words: pineapple, juice, agglomerate, physical and chemical properties

Abstract

Pineapple juice can be converted to powder or agglomerate by the process of fluidized bed drying and agglomeration. Ground sugar was used as a carrier while other essential minor additives i.e. anhydrous citric acid, pineapple flavour and permitted food colour, were used to boost up flavour, sugar-acid balance and eye appeal of the product. Optimum process variable used were 40 °C as the process temperature, 20 m³/ha 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 6 g/min. Fresh pineapple 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 43.82% and the fruit moisture content was relatively high at 88.36%. The strained juice was light yellow with colour value of $L^* = 44.44$, $a^* = 1.14$, $b^* = 25.43$, total titratable acidity (TTA) = 0.47%, pH = 3.75, total soluble solids (TSS) = 9.5 and viscosity = 2.55 cP. Particle size distribution of the agglomerate showed that less than 10% of the particles were retained on the larger mesh no. i.e. mesh nos. 20, 30, 40 and 45.

About 15% of the particle size was between 250–300 µm and 45% of the particles were finer than 250 µm. The colour of the pineapple agglomerate was $L^* = 90.57$, $a^* = -0.51$, $b^* = 25.93$, the bulk density was 0.67 g/ml and the moisture content was 3.1%. The pineapple drink was compared to the fresh pineapple juice which had colour values of $L^* = 64.62$, $a^* = 0.53$, $b^* = 25.90$, the TTA was 0.40%, the pH was 2.88 and the TSS was 9.0. The viscosity was slightly more viscous than the juice at 2.77 cP.

Results of sensory evaluation showed that there were no significant differences in the colour, flavour, sweetness, sourness and overall acceptability of the drink and the juice. However, all the attributes had higher scores given to the juice except for the overall acceptability which was given the same score for both the drink and juice. The chemical analysis of the pineapple agglomerate showed that the total sugar content, total carbohydrate content and energy values were high because sugar was used as the carrier. The values of the other elements were considered relatively low except for the potassium content for the pineapple agglomerate as compared to the orange flavoured drink powder which had high contents of calcium, sodium, potassium and vitamin C. This can be explained by the fact that fortification of the orange flavoured drink powder was added to boost up the values of these contents.

*Mechanisation and Automation Research Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774

Kuala Lumpur, Malaysia

Author's full name: Lee Siew Yoong

E-mail: sylee@mardi.my

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Introduction

Pineapple juice is the juice extracted from the edible portion of the pineapple fruit by mechanical means. It is sold unsweetened or sweetened in cans and bottles and as frozen concentrate and used in many beverages from ordinary juice drinks to mixed beverages. It is commonly known that pure juice derived from fruits is healthy. Fruit juice represents many people's favourite beverages. Juices are now accepted worldwide as additives or supplements for many drinks (Buchwald 1988). Moreover, fruit juice drinks are marketed as fitness drinks and consumers like their 'naturalness'. They also like the taste and the convenience (Williams 2001).

Fruit drinks are increasingly being served with dinners, the percentage has gone up from 5% in 1999 to 5.8% in 2000 (Sloan 2001). Juice or ingredients derived from tropical fruits such as banana, pineapple, mango and passion fruit may be used to add functionality to beverages. In addition to providing functionality to beverages and benefits such as texture and flavour, they have potential health benefits (Pszczola 2001).

Juice has an extremely short shelf life, therefore it requires either heat-treatment or chemical preservation or some form of processing to extend its shelf life or to convert it into another product. One of the oldest forms of processing is dehydration which can be applied to juice preservation. Besides freeze drying, drum drying and spray drying, fluidized bed drying and agglomeration is becoming more popular to dry fruit juices.

A fluid bed system offers the possibility of an on-line processing as it allows other ingredients to be sprayed onto the powder layer in the fluid bed to achieve large, stable agglomerates. Agglomerates are powdered ingredients which are made to adhere together to form larger particles in order to achieve improved physical characteristics such as flowability and dispersibility (Schmitt 1997). Powders to be

instantized or coated are fluidized and sprayed with desired liquid (i.e. water, solution of binder, coating material or flavour paste/oil) which has been atomized to a fine mist. Alternate cycles of spraying under controlled conditions of temperature and fluidization produce agglomerates or coated particles as desired (Duxbury 1988).

The juice, which has been converted to agglomerates, has specific properties such as physical and chemical properties which are important in defining the product. Physical properties of food may be defined as those properties that determine and quantify quality factors that govern consumer acceptance, suitability of the product for specific uses and thus, its economic value (Peleg and Bagley 1983). Not only the physical properties of foods are important, the chemical properties play an equally important role. There is very little information on properties of agglomerated powder from fruits especially tropical fruits. This study was undertaken to study the physical and chemical properties of agglomerated pineapple powder and the drink produced from fluidized bed drying of pineapple juice and the agglomeration process.

Materials and methods

Fruit

Ananas comosus (L) variety Moris with colour index 6 (Anon. 2003) was purchased locally from a market and stored at ambient temperature for 24 h before processing. The fruit was deskinning manually, sliced 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 a 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 evaluated using ASTM mesh no. 20, 30, 40,

45, 50 and 60 on a Rotap device (Endecott Test Sieve Shaker, England) for 5 min. A sample of 1 kg 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 pineapple flavour (Product code 258401, Bayer Malaysia Sdn. Bhd.) anhydrous citric acid (Shin Heng Chemical Sdn. Bhd, Malaysia) and permitted food colour (Boustead Engineering Sdn. Bhd., Malaysia). From preliminary trials, about 1% of pineapple flavour based on 1 kg sugar was adequate for the product.

As for the colour, a solution weight of 1 g taken from 1% stock solution of sunset yellow and a solution weight of 2 g taken from 1% stock solution of tartrazine were adequate for the product. About 3% (30 g) of anhydrous citric, based on 1 kg of sugar, was mixed thoroughly with the carrier. It was found that this amount of citric acid produced a suitable sugar-acid level for this product. Pineapple flavour (10 g) and food colour (1 g of sunset yellow and 2 g of tartrazine) were added to 40 g of fresh pineapple juice to be used as a binder 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 pineapple juice.

Equipment and instrumentation

The fluidized bed dryer and agglomerator (Glatt model GPCG1, Germany) has a vertical column as the drying chamber and a product container which is cylindrical or slightly conical and was a 200 μ m mesh at its base. The product container is placed in the machine during operation and heated air is drawn through the mesh to fluidize the carrier. A pneumatic sprayer with a nozzle is

fixed at the upper position of the vertical column. The capacity of the equipment is 1–1.5 kg bed load. Inlet temperature of the fluidizing air, product temperature in the drying chamber and exhaust temperature were displayed by LEDs on the control panel. The product and filter differential pressure, airflow rate, atomization pressure were displayed on the control panel. These variables were recorded and printed on paper at 60 second intervals.

Process variable

The spraying process was carried out by an atomiser 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 used 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 6 g/min. The total drying and agglomeration duration was 3 h. The amount of pineapple juice sprayed during the drying and agglomeration process was 1 kg.

Fluidized bed drying and agglomeration process

The process variable 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 temperature (Lee 2000). A sample of 1 kg of ground sugar with mean particle size of 425 μ 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 to 40 °C. The shaking device was activated at 10 s interval for duration of 5 s to prevent product from sticking to the filters.

When the operating conditions were stable, 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. This was immediately followed by spraying of fresh pineapple juice. The spraying of fresh pineapple juice continued for 3 h until the product was well agglomerated and fluidized by the velocity. After spraying was terminated, drying process continued for another 30 m to ensure the pineapple 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 before product analysis was carried out (*Figure 1*).

Physico-chemical characteristics 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* and b* values. Triplicate readings of the moisture content (wet basis) of the macerated pineapple 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.

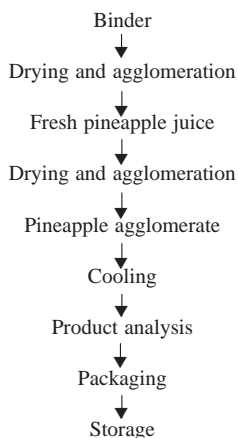


Figure 1. Drying and agglomeration of pineapple juice

The juice pH was determined using the WTW pH meter (Werkstätten, Germany). Total soluble solids (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 citric acid (AOAC 1990). Triplicate readings of the juice colour were determined for L*, a* and b* values.

Product analysis

The pineapple agglomerate was sieved through ASTM mesh no. 20, 30, 40, 45, 50, 60 on a Rotap device (Endecott Test Sieve Shaker, England) to determine the particle size distribution. Triplicate readings of the pineapple agglomerate colour was determined for L*, a*, and 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. Chemical analysis of the pineapple agglomerate was carried out by using the AOAC Official Methods (AOAC 1990). The chemical analysis carried out was protein, fat, ash, crude fibre, total sugars, energy, dietary fibre, calcium, iron, sodium, potassium, vitamin C and A.

Pineapple drink

Pineapple drink was obtained by dissolving 100 g of agglomerate in 1 litre of water at 5 °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 pineapple drink. Sensory evaluation of the pineapple drink

compared to the fresh pineapple juice was carried out by 20 panellists in individual booths illuminated by fluorescent light in air-conditioned sensory evaluation laboratory. Panellists were instructed to evaluate the flavour, sweetness, sourness, colour and overall acceptability using a 9-point hedonic scale where 1 = dislike extremely and 9 = like extremely.

Sampling

A total of 20 batches of processed products were carried out every month over a period of 12 months. Out of these 12 batches, 3 batches were randomly selected for the purpose of this paper. The results presented in this paper are the average values of 3 batches.

Results and discussion

Juice recovery was moderately low at 43.82% and the moisture content of the fruit was relatively high at 88.36%. The strained juice was light yellow with colour values of $L^* = 44.44$, $a^* = 1.14$, $b^* = 25.43$ (Table 1). The TTA level was low at 0.47% which is typical of this variety (Chan 1993). The pH was low at 3.75, the TSS was moderately low at 9.5 and the juice can be considered as a non-viscous fluid at 2.55 cP.

The colour of the pineapple agglomerate was light yellow ($L^* = 90.57$, $a^* = -0.51$, $b^* = 25.93$). The bulk density of the pineapple powder was 0.67 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 pineapple powder was 3.1%, well within the acceptable range of powdered product such as milk powder which has moisture content of 2–4% (Peleg and Bagley 1983).

Particle size distribution (Washington 1992) of pineapple agglomerate (Table 2) showed that less than 10% of the particle was retained on the larger mesh no. i.e. mesh no. 20, 30, 40 and 45. About 15% of the particle size was between 250–300 μm and 45% of the particles was finer than

Table 1. Mean value* of colour, TTA, pH, TSS and viscosity of pineapple juice and drink

Characteristics	Drink	Juice
Colour		
L^*	64.62	44.44
a^*	0.53	1.14
b^*	25.90	25.43
Total titratable acidity (%)	0.40a	0.47a
pH	2.88a	3.75b
Total soluble solids	9.0a	9.5a
Viscosity at 30 °C (cp)	2.77a	2.55a

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

*Average of three batches

Table 2. Particle size distribution* of pineapple agglomerate

Mesh no.	Size (μm)	% Retained
20	850	9.10 ± 1.93
30	600	2.08 ± 2.81
40	425	8.78 ± 2.44
45	355	7.93 ± 4.94
50	300	12.18 ± 1.91
60	250	14.88 ± 3.21
Pan	–	45.06 ± 4.72

250 μm indicating more fines were produced. This particle size distribution of such nature was produced as a result of agglomeration, considerably increased the surface area of this product to produce the desired porous structure. When this product is reconstituted through wetting of the agglomerate, the fluid penetrates into the hollow interior space as a result of capillary absorption, dissolving the hollow bridges so that the individual particles come apart and are distributed in the fluid (Schmitt 1997). The reconstitution of pineapple agglomerate in either cold or warm water produced a pineapple drink which is commonly known as dispersion or solubility.

From preliminary sensory evaluation trials, a dispersion rate of 100 g of agglomerate in 1 litre of water at 5 °C produced acceptable flavour, sweetness, sourness and colour of the pineapple drink (Lee 2000). The colour of the pineapple drink was light yellow with value of

Table 3. Average scores for colour, flavour, sweetness, sourness and overall acceptability of pineapple drink and juice

	Colour	Flavour	Sweetness	Sourness	Overall acceptability
Drink	6.7a	6.3a	6.3a	6.2a	6.3a
Juice	6.9a	6.5a	6.5a	6.3a	6.3a

Mean values with different letters in each column are significantly different ($p < 0.05$) based on t-test Using a 9-point hedonic scale where 1 = dislike extremely and 9 = like extremely

Table 4. Mean values of chemical analysis of pineapple agglomerate and orange flavoured drink powder (composition in 100 g)

Chemical analysis	Pineapple agglomerate	Orange flavoured drink powder*
Protein (N x 6.25) (g)	0.3	0.1
Fat (g)	1.3	0.0
Ash (g)	0.2	1.2
Crude fibre (g)	0.2	0.0
Total sugars (g)	93.5	N.A.
Total carbohydrate (g)	95.5	97.8
Dietary fibre (g)	0.0	N.A.
Energy (Kcal)	395.0	392.0
Calcium (mg)	4.0	12.0
Iron (mg)	0.8	0.2
Sodium (mg)	1.7	91.0
Potassium (mg)	70.0	236.0
Vitamin C (mg)	5.3	150.0
Vitamin A (mg)	3.0	0.0

*Tee et al. (1997)

N.A. = Not analysed

$L^* = 64.62$, $a^* = 0.53$ and $b^* = 25.90$ (Table 1) which was similar to the pineapple juice. The TTA of the pineapple drink and pineapple juice, 0.40% and 0.47% respectively, was significantly not different from each other. The pH of the pineapple drink was 2.88 which was significantly different from the pineapple drink at 3.75. The TSS of the pineapple drink and pineapple juice, 9.0 and 9.5 respectively, was significantly not different from each other. The viscosity of the pineapple drink and pineapple juice was significantly not different from each other at 2.77 cP and 2.55 cP respectively. The pineapple drink had values close to the values of the juice therefore had the acceptable characteristics of a fruit beverage.

Results of sensory evaluation (Table 3) showed that there was no significant difference in the colour, flavour, sweetness, sourness and overall acceptability of the drink and the juice. However, all the

attributes had higher scores given to the juice except for the overall acceptability which was given the same score for both the drink and juice.

The chemical analysis of the pineapple agglomerate (Table 4) showed that the total sugar content was high because sugar was used as the carrier. Consequently the total carbohydrate content and energy values were also high. Similarly, these values were reported to be high for the orange flavoured drink powder. The values of the other elements were considered relatively low except for the potassium content for the pineapple agglomerate as compared to the orange flavoured drink powder which had high contents of calcium, sodium, potassium and vitamin C. This can be explained by the fact that fortification of the orange flavoured drink powder consisted of calcium phosphate, sodium carboxymethylcellulose, acesulfame potassium, vitamin C and other elements were added to boost up the values

of these contents. As for the pineapple agglomerate, no fortification was carried out but only fresh pineapple juice and some essential minor additives were added such as sugar, citric acid, pineapple flavour and permitted food colours.

Conclusion

Pineapple agglomerate produced by fluidized bed drying and agglomeration process using ground sugar as a carrier produced an acceptable ready-to-drink fruit beverage. Suitable process variables were used during fluidized bed drying and agglomeration. The pineapple juice played a major role as a binder for successful agglomeration which produced a range of suitable particle size for rapid dispersion in water. The perceived flavours of the pineapple drink depended upon several chemical attributes of the product, namely TTA, pH and TSS which were contributed by the pineapple juice as well as the essential minor additives. Pineapple agglomerate was analysed to have low values of nutrient contents except for the total sugars. Nutritionally, pineapple agglomerate can be easily enriched by fortification with nutritional additives which are commercially available.

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Abstrak

Jus nanas boleh dijadikan serbuk atau aglomerat dengan menggunakan proses pengeringan 'fluidized bed' dan pengaglomeratan. Gula kisar digunakan sebagai pembawa manakala bahan tambahan seperti asid sitrik, perisa dan pewarna makanan diperlukan untuk menambah perisa dan mengimbangkan asid-gula serta untuk kelihatan menarik. Parameter proses yang optimum digunakan iaitu suhu 40 °C, kadar aliran isi padu udara 20 m³/jam yang menghasilkan had laju 1.5 m/saat, tekanan pengabus 3 bar dan kadar alur pam 6 g/minit. Jus nanas digunakan sebagai 'binder' untuk proses pengaglomeratan pada permulaan proses pengeringan.

Kadar perolehan jus ialah 43.82% dengan lembapan buah 88.36%. Ciri-ciri jus yang dianalisis ialah nilai warna $L^* = 44.44$, $a^* = 1.14$, $b^* = 25.43$, jumlah asid tertitrat (TTA) = 0.47%, pH = 3.75, jumlah pepejal larut (TSS) = 9.5 dan kelikatan = 2.55 cP. Analisis produk aglomerat seperti saiz-zarah menunjukkan lebih kurang 10% saiz-zarah dibendung pada jaringan yang agak besar iaitu pada jaringan no. 20, 30, 40 dan 45. Sebanyak 15% saiz-zarah antara 250–300 µm dan sebanyak 45% saiz-zarah lebih kecil daripada 250 µm. Warna aglomerat ialah $L^* = 90.57$, $a^* = -0.51$, $b^* = 25.93$, ketumpatan pukal = 0.67 g/ml dan lembapan = 3.1%. Ciri-ciri produk minuman nanas seperti warna ialah $L^* = 64.62$, $a^* = 0.53$, $b^* = 25.90$, TTA = 0.40%, pH = 2.88, TSS = 9.0 dan kelikatan = 2.77 cP.

Keputusan ujian nilai rasa menunjukkan tiada perbezaan antara minuman nanas dengan jus nanas terhadap ciri-ciri seperti warna, aroma, kemanisan, kemasaman dan penerimaan keseluruhan. Walau bagaimanapun untuk kesemua ciri nilai rasa, markah yang lebih tinggi diberi kepada jus nanas kecuali untuk ciri penerimaan keseluruhan di mana markah yang sama diberi kepada minuman dan jus nanas.

Analisis kimia terhadap aglomerat menunjukkan nilai jumlah gula, jumlah karbohidrat dan nilai tenaga adalah tinggi kerana gula digunakan sebagai pembawa. Nilai untuk elemen yang lain kecuali kalium adalah rendah bagi aglomerat jika dibandingkan dengan serbuk minuman berperisa oren yang mempunyai nilai kalsium, natrium, kalium dan vitamin C yang tinggi. Keadaan ini disebabkan serbuk minuman berperisa oren diperkuat dengan bahan-bahan yang mempertingkatkan nilai-nilai elemen ini.