

Development of a Small Scale Processing System for Concentrated Ginger Powders

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Abstract: Mature ginger rhizomes with the age of 10-12 months was used in the study. Ginger juice was extracted using a hydraulic press and evaporated in traditional pan, natural circulation and agitated vacuum evaporators. The evaporators had no significant difference on a_w , solubility, water solubility index, water absorption index and bulk density of concentrated ginger powders ($p > 0.05$). The natural circulation and agitated vacuum evaporators provided higher lightness of concentrated ginger powders than traditional pan evaporator ($p \leq 0.05$). However, the evaporators had no significant difference on yellowness (a^*/b^*) of concentrated ginger powders and L^* and a^*/b^* of reconstituted ginger powders. The agitated vacuum evaporator provided the highest 6-gingerol remaining ($p \leq 0.05$).

Key words: Evaporator • Concentrated ginger powder • Ginger • 6-gingerol

INTRODUCTION

One of the key unit operations for fluid food products is evaporation, as utilized to concentrate or increase the solid concentration of a fluid food. One of the primary objectives of this operation is to reduce the volume of nutrient components. This reduction of volume permits more efficient transportation of the important product components and efficient storage of the solids. An equally important objective of evaporation of moisture from fluid foods is to remove large amounts of moisture effectively and efficiently before the product enters a dehydration process. Due to the heat sensitivity of most products, evaporation is usually accomplished under vacuum. By utilizing relatively high vacuum (low pressures), large amounts of moisture can be removed from liquid food products without significant reduction in the quality of heat-sensitive components [1]. Concentrated ginger powders were made by traditional method. Ginger rhizomes were cleaned and cut into pieces. Ginger juice was obtained by hydraulic pressing and concentrated in a pan under atmospheric pressure at a temperature of 100-105°C. Sugar was added to the ginger juice and evaporated until sugar crystallization took place. Due to the high boiling point of 100-105°C, heat sensitive components were destroyed.[2] Mango pulp was evaporated in two kinds of evaporator, namely, a pan evaporator and an increased surface area evaporator which were operated under vacuum. The efficiency of the

increased surface area evaporator was higher than the pan evaporator because of lower evaporation times of 3 folds and lower steam economy of 2.1 folds. However, the pan evaporator provided slightly higher yield than the increased surface area evaporator. The results revealed that the increased surface area evaporator retained better color change than the pan evaporator [3]. Concentrated grape juices are produced during harvest and supplied throughout the year to other manufactures for the production of reconstituted grape beverages. Samples of grape cultivars were obtained at each step of the industrial process which consisted hot pressing of grapes and pasteurization of must (80°C, 30s) followed by filtration and concentration of juice to 68°Brix by evaporation (highest temperature of 98°C for 5s).[4]

The objectives of this work were to design and develop a simple agitated vacuum evaporator for a small scale processing system for concentrated ginger powders in order to retain the highest 6-gingerol. Quality aspects of the ginger powders, such as moisture content, a_w , solubility, water solubility index, water absorption index, bulk density, color values and 6-gingerol were also performed.

MATERIALS AND METHODS

Ginger Juice Preparation: Mature ginger rhizomes (*Zingiber officinale* Roscoe) with the age of 10-12 months [5] were cleaned in 5 ppm chlorinated water and

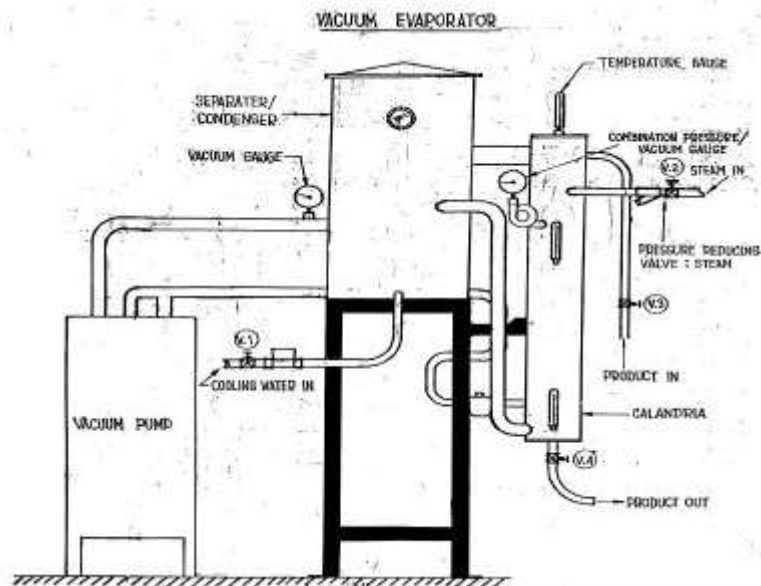


Fig. 1: Natural circulation evaporator Form: Wicham [6]

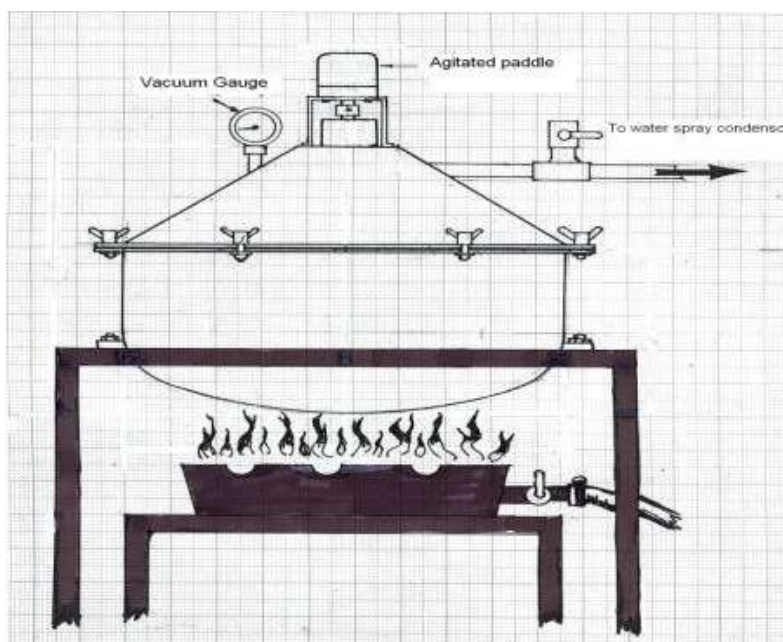


Fig. 2: Agitated vacuum evaporator

cut into small pieces. Ginger juice was extracted using a hydraulic press (Samson, Heavy Duty, Bangkok, Thailand).

Ginger Drink Powder Processing: Evaporation of ginger juice was performed in three evaporators, namely traditional pan evaporator, natural circulation evaporator and agitated vacuum evaporator.

- Traditional pan evaporator: One and a quarter of a kilogram of refined sugar plus 1.25 kg of brown sugar were added to 1 kg of ginger juice. The sugar-ginger juice mixture was evaporated and crystallized under atmospheric pressure at $100 \pm 5^\circ\text{C}$ for 30 min. Concentrated ginger powders were dried in a cabinet dryer (Pasteur Ltd. Partnership, Bangkok, Thailand) at 60°C for 1 hour [2].

- Natural circulation evaporator [6]: Ten kilograms of ginger juice (3°Brix) was evaporated in a natural circulation evaporator (Figure 1) at 85°C under vacuum of -10 in Hg (-33.86 kPa). Steam pressure of 10 lb/in² (68.95 kPa) at temperature of 115°C was used to evaporate ginger juice to 6°Brix for 5 min. Half of one kilogram (equivalent to 1 kg ginger juice) of concentrate juice was mixed with 1.25 kg refined sugar and 1.25 kg brown sugar and crystallized in a pan for 15±2 min. Concentrated ginger powders were dried in the cabinet dryer (Pasteur Ltd. Partnership, Bangkok, Thailand) at 60°C for 1 hour.
- Agitated vacuum evaporator: In this work, an agitated vacuum evaporator was designed for small and medium enterprises (SMEs). Three basic components were required to accomplish evaporation, as illustrate in Figure 2. The evaporator utilized for fluid food products contained the following:
 - a An evaporation vessel. The evaporation vessel consisted a diameter of 0.47 m, a height of 0.26 m and capacity of 40 liters and an agitated paddle (0.28m length) with a speed of 50 rpm.
 - b A heat source using LPG burner. The LPG consumption was 0.25 kg/h.
 - c A Condenser. Water spray designed by Wicham (1978) was used to maintain vacuum in the evaporation vessel.

One and a half kilogram of ginger juice (3°Brix) was evaporated in the agitated vacuum evaporator at 54°C under vacuum of -26 in. Hg (-88.05 kPa). Steam was not used in this evaporator. The evaporator was maintained under vacuum using the water spray system and evaporated ginger juice to 6°Brix for 25 min. Half of one kilogram (equivalent to 1 kg ginger juice) of concentrated juice was mixed with 1.25 kg refined sugar and 1.25 kg brown sugar and crystallized in the pan for 15±2 min. Concentrated ginger powders were dried in the cabinet dryer (Pasteur Ltd. Partnership, Bangkok, Thailand) for one hour. Completely Randomized Design (CRD) was used to study the factors affecting concentrated ginger powders. Two replications were used to determine the main factors. SPSS version 16 for Window was used to calculate analysis of variance (ANOVA).

Moisture Content: Moisture content of concentrated ginger powders was determined using the oven method

[7]. Sample of 5 g was dried in an oven (U30, Memmert, Germany) at 105°C for 3 h. Moisture was calculated from the weight difference between the original and dried sample and expressed as percentage of the original sample.

Water Activity (a_w): Concentrated ginger powders of 0.5 g were determined using a water activity meter (AQUALAB series 3TE, Device Co., Germany) at 25°C.

Solubility: Solubility was determined using the method modified by Al-Kahtani and Bakri [8]. A small sample of concentrated ginger powders of 0.6 g was added to 400 ml of water at 70°C in a 500 ml beaker. The mixture was stirred using a magnetic stirrer at 7 rpm. Solubility was timed in seconds used to dissolve the concentrated ginger powders completely.

Bulk Density: Bulk density was determined by adding 20 g of concentrated ginger powders to a 50 ml graduated cylinder and holding the cylinder on vibrator for 1 min. The bulk density was calculated by dividing mass of the powders by the volume occupied in the cylinder [9].

Water Solubility Index (WSI) and Water Absorption Index (WAI): Water solubility index and water absorption index were determined using the method described by Gomez *et al.* [10]. A small sample of concentrated ginger powders (2.5 g) was added to 30 ml of water at 30°C in a 50 ml centrifuge tube, stirred intermittently for 30 min and then centrifuged for 10 min at 5,000 rpm. The supernatant was carefully poured off into a petridish and oven-dried overnight. The amount of solid in the dried supernatant as a percentage of total dry solids in original 2.5 g sample gave an indication of water solubility index. Wet solid remaining after centrifugation was dried in an oven (U30, Memmert, Germany) overnight. WAI was calculated as the weight of dry solid divided by the amount of dry sample.

Color Values: The color of concentrated ginger powders was determined using Hunter Lab (Ultra Scan XE U3115, Colorglobal Co., America). The color was measured in terms of Hunter L*, a* and b* values. Hunter L* represents the lightness or darkness of the object and it is measured on a scale of 0 to 100. L* values of 100 represents white and L* of 0 represents black. Hunter a* represents redness (+) or greenness (-).

Hunter b* represents yellowness (+) or blueness (-) [11]. The samples were ground using a grinder and a sample size of 5 g was used for color measurements. For each sample, three replications of color test were performed.

Determination of 6-gingerol by High Performance Liquid Chromatography: 6-Gingerol of concentrated ginger powders was determined using the method modified from Balladin *et al.*[12] A sample of dry powders (1 g) was extracted in 10 ml methanol overnight and then centrifuged for 10 min at 5,000 rpm. The supernatant was filtered through a Whatman paper No.2 and then the filtrate was filtered through a 0.45 μ nylon filter. Reverse-phase high performance liquid chromatography (HPLC) was used for the determination of 6-gingerol in the extract of ginger powders. Twenty μ l of the extract was injected into the HPLC. The water HPLC system was used. The column was a reverse-phase H15C₁₈ (150 mm x 4.6 mm), id 5 μ m (HiChrom Co.) with Nova-Pack C_{18} pre-column (Water Co.). The mobile phase was methanol: double deionized water (70:30 v/v). The solvent flow rate was 1.2 ml/min. The UV detector (WaterTM 480) was monitored at 282 nm. The correlation regression of external standard curve was 0.998. Area under a curve of a sample was determined the 6-gingerol content using the external standard curve.

RESULTS AND DISCUSSION

Evaporation of ginger juice was performed in three evaporators, namely traditional pan evaporator [2], natural circulation evaporator [6] (Fig.1) and agitated vacuum evaporator of this work (Fig. 2). The ginger juice was evaporated from 3°Brix to 6°Brix or the concentration was

increased to double the original concentration. Qualities of concentrated ginger powders are illustrated in Table 1. The results indicated that the types of evaporators did not affect a_w , solubility, water solubility index and bulk density of dried concentrated ginger powders ($p>0.05$). However, the types of evaporator influenced moisture content and lightness of the products. The natural circulation and agitated vacuum evaporators provided higher moisture content than traditional pan evaporator because of higher evaporation temperature of $100\pm5^\circ\text{C}$ and longer evaporation times of 30 min of the traditional pan evaporator ($p\leq 0.05$).

Color values of concentrated ginger powders were shown in Table 2. Lightness of concentrated ginger powders obtained from the agitated vacuum evaporator was higher than the product obtained from the traditional pan evaporator due to also the lower evaporation temperature. The agitated vacuum evaporator could maintain at very low vacuum of -26 in. Hg so that the boiling point of ginger juice during the evaporation decreased to 54°C , whereas the boiling point of ginger juice in the traditional pan and natural circulation evaporators were $100\pm5^\circ\text{C}$ and 85°C , respectively. By utilizing relatively high vacuum (low pressures and temperatures [1, 13, 14], large amount of moisture can be removed from liquid food product without significant reduction in the quality of heat sensitive components [1].

6-Gingerol remaining of concentrated ginger powders was shown in Table 3. Figure 3 illustrate chromatograms (6-gingerol) of standard and concentrated ginger powders from agitated vacuum evaporator. The results revealed that types of evaporation affected 6-gingerol remaining. The agitated vacuum evaporator provided higher

Table 1: Moisture content, water activity, solubility, water solubility index (WSI), water absorption index (WAI) and bulk density of concentrated ginger powders

Types of evaporator	Moisture content (% d.b.)	a_w	Solubility (s)	WSI(%)	WAI(%)	Bulk density (kg/m ³)
Pan evaporator	1.00 ± 0.18^b	0.63 ± 0.02	14.62 ± 0.09	96.34 ± 0.29	1.516 ± 0.00	860.40 ± 0.00
Natural circulation evaporator	1.26 ± 0.03^a	0.65 ± 0.00	14.76 ± 0.07	96.53 ± 0.40	1.517 ± 0.00	866.1040 ± 0.00
Agitated vacuum evaporator	1.25 ± 0.02^a	0.64 ± 0.00	14.74 ± 0.15	96.43 ± 0.33	1.516 ± 0.00	866.50 ± 0.00

a, b superscripts are significantly different ($p\leq 0.05$)

Table 2: Color values of concentrated ginger powders

Type of evaporator	Concentrated ginger powders		Reconstituted ginger powders	
	L*	a*/b*	L*	a*/b*
Pan evaporator	77.04 ± 0.41^b	0.141 ± 0.00	33.50 ± 0.06	-0.47 ± 0.04
Natural circulation evaporator	77.26 ± 0.35^{ab}	0.144 ± 0.00	33.49 ± 0.02	-0.42 ± 0.13
Agitated vacuum evaporator	77.62 ± 0.16^a	0.146 ± 0.00	33.59 ± 0.02	-0.50 ± 0.02

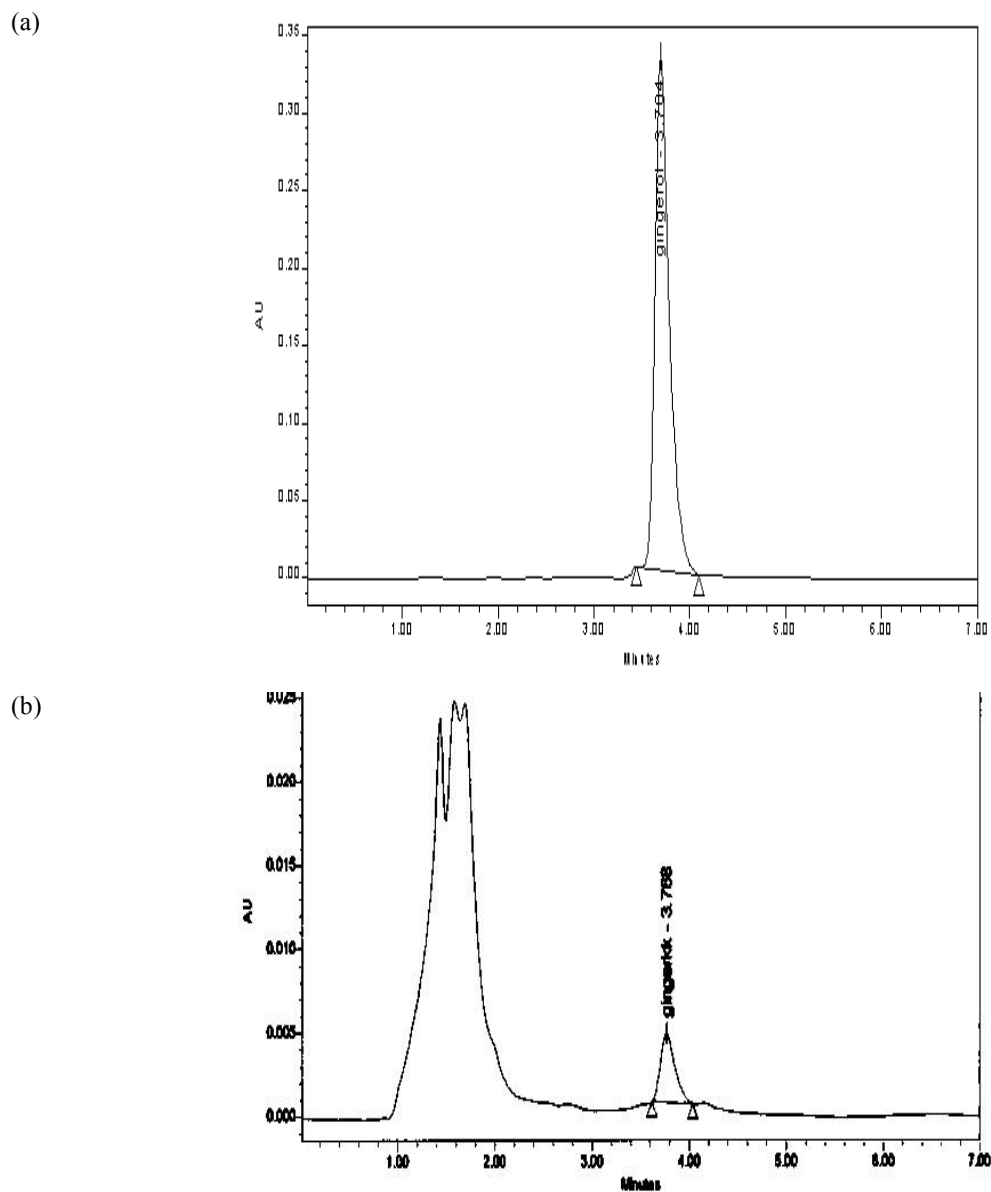


Fig. 3: Chromatograms (6-gingerol) (a) standard (b) concentrated ginger powders from agitated vacuum evaporator

Table 3: 6-Gingerol content of concentrated ginger powders

Types of evaporator	6-gingerol (ppm)
Pan evaporator	286.96 \pm 4.94 ^{bc}
Natural circulation evaporator	306.43 \pm 26.18 ^b
Agitated vacuum evaporator	675.65 \pm 35.22 ^a
SME	220.51 \pm 27.53 ^c

a, b superscripts are significantly different ($p \leq 0.05$)

6-gingerol remaining than natural circulation evaporator, traditional pan evaporator and commercial product because of the lowest evaporation temperature at 54°C. According to the heat sensitive of moist

products, evaporation is usually accomplished under vacuum to decrease the boiling point of the products without significant reduction in the quality of heat sensitive components [1].

CONCLUSIONS

Ginger juice was evaporated in traditional pan, natural circulation and agitated vacuum evaporators. The natural circulation and agitated vacuum evaporators provided higher lightness of concentrated ginger powders than traditional pan evaporator

($p \leq 0.05$). The agitated vacuum evaporator provided the highest 6-gingerol remaining ($p \leq 0.05$).

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