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Determination of Critical Processing Parameters during Instant Ginger Drink Production in Small Scale Industry

TETI ESTIASIH[1]*, KGS AHMADI[2] and INDRIA PURWANTININGRUM[1]

[1]Department of Food Science and Technology, Faculty of Agricultural Technology, Brawijaya University, Malang, Indonesia.
[2]Department of Agroindustrial Technology, Faculty of Agriculture, Tribhuwana Tunggadewi University, Malang, Indonesia.

Abstract

Ginger is very rich in bioactive compounds and has beneficial effects on health. Ginger based products are assumed as herbal to prevent diseases and maintain health. One of ginger based products is instant ginger drink. This product is processed simply, principally by crystallization of sugar. This study was aimed to determine critical processing parameters, as well as control and critical control points during instant ginger drink production at small scale industry. Processing parameters evaluation were method of size reduction (grating and blending), sedimentation time, and ginger to sugar ratio. Analysis of control and critical control points were performed for all steps of processing. The result showed that method of size reduction did not affect time and yield. Sedimentation time affected residual starch content of ginger extract. Ginger to sugar ratio had significant effect on crystallization time. Control points and critical control point have been established for instant ginger drink production. All steps in instant ginger drink processing are control points, except crystallization which is a critical control point.

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Keywords

Control point;
Critical control point;
Crystallization;
Extract;
Ginger.

Introduction

Ginger is one of the most widely used spices of the ginger family and is a common condiment for various food and beverages[1]. Ginger is very rich in bioactive compounds such as 6-gingerol and 6-paradol[2]. Many studies revealed that ginger has beneficial effects on health. Gingerol from ginger has antioxidant and anti-inflammatory properties[3]. The main pharmacological actions of ginger and compounds isolated therefrom include immuno-modulatory, anti-tumorigenic, anti-inflammatory, anti-apoptotic, anti-hyperglycemic, anti-lipidemic and anti-emetic actions. Ginger is a strong anti-oxidant substance and may either mitigate or prevent generation of free radicals[4]. [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol exhibited substantial

CONTACT Teti Estiasih teties@ub.ac.id Department of Food Science and Technology, Faculty of Agricultural Technology, Brawijaya University, Malang, Indonesia.

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scavenging activities[5]. Gingerol extract from Zingiber officinalehas anti ulcer activity[6]. It is considered a safe herbal medicine of ginger with only a few and insignificant adverse/side effects[4].

In many countries, ginger is usually used as a spice in many traditional foods. Ginger is also usually used in some traditional beverages such as wedang, bajigur, bandrek, etc,in Indonesia. In Philippine, ginger is brewed into the native beverage tahu or salabat. In Corfu island, Greece, a traditional drink called tsitsibira, a type of ginger beer is made. In Carribean, ginger is used in a drink called sorrel, a seasonal drink made during Christmas season. Jamaicans make ginger beer as carbonated beverage[7]. These traditional beverages have a complicated and long preparation, although some of them have been improved into instant beverages that easy to prepare and serve.

Another ginger based beverage in Indonesia is instant ginger drink is that made from ginger extract and cane sugar. The process to produce instant ginger drink is quite simple that involves extraction to obtain ginger extract and cooking of extract ginger with sugar cane. During cooking, water evaporates and sugar crystallizes fast. Thoroughly stirring during heating makes crystallization of the sugar and ginger extract to occur. This product has been widely accepted as a healthy drink. This product is easy to serve by diluting the powder in water.

Manufacturing of instant ginger drinkis generally done by small food enterprises. This product can also be made in household scale. Processing standardization of the instant ginger drink production is required to assure that this product always has good quality from batch to batch. Critical processing parameters in producing this healthy drink in small scales should be determined. Also, determination of control points and critical control points is very important in instant ginger drink quality assurance.

Materials and Methods

This study was conducted in small scale instant ginger drink manufacture UKM "DIA" at Malang, East Java Province, Indonesia. Materials used were fresh ginger roots from local farmers, and sugar cane from a local market. Chemical reagents pro analysis was used for analysis of quality parameters, including sulfuric acid, Nelson reagent, arsenomolybdate, cupro oxide, and ethanol. Equipment used in instant ginger preparation included blender, stove,frying pan, and filter cloth. Equipment used for analysis comprised of spectrophotometer uv-vis (Biochrom), water bath shaker (Memmert), and glassware.

Instant Ginger Drink Manufacture

Instant ginger drink production was started from washing 500 g of ginger roots and reducing the size of the roots. A grating machine was used, meanwhile blending was done by adding water until water to ginger ratio was 1:1. Grating was performed continuously, and blending was done by using blender with capacity 1 L in volume for 10 min. After size reduction, crumble ginger was pressed. Then the filtrate was deposited for different periods of time according to the treatment. Afterwards, the filtrate was mixed with cane sugar to obtain a different ratio. Time for cooking was measured. The cooking (evaporation of water and stirring) was ended when the crystal nucleus was formed and that was indicated by solidification of the ginger extract and sugar mixture. The stirring was continued without further heating to let all the sugar crystallized. The crystal was then sieved 20 mesh to obtain powder instant ginger drink.

Determination of Critical Processing Parametres

Some steps in production of instant ginger drink were evaluated including method of (1) size reduction of ginger roots, (2) duration of sedimentation, and (3) duration of cooking with different sugar concentration. Methods of size reduction used in examination were grating and extraction using blender (blending). Duration of sedimentation evaluated was 10, 60, and 720 min. Different ginger to sugar ratio (w:w) of 1:1; 1:1,5; 1:2; 1:2,5 was examined. The last treatment was conducted in the small quantity, that was 500 g of ginger. Therefore, in this experiment time required for crystallization will be different to larger quantities such as in the small industrial scales. However, the result of this experiment can be used as the basic to determine the ratio of ginger to sugar, although in the larger scales.

Analysis of yield and duration of size reduction were conducted to evaluate the method of size reduction. Starch was analysed after sedimentation by method

of AOAC Official Method 996.11. Sedimentation of ginger extract after size reduction was conducted by leaving the extract for certain time according to the treatments. Filtrate was taken from the extract manually and the starch was removed.Time of cooking was measured to evaluate the ratio of ginger to sugar. All treatments were repeated three times each. All data was statistically analysed by analysis of variance (Anova), and further analysed by Least Significant Different test to know the difference between treatment by using MS Excel 2007.

Determination of Control Points (CP) and Critical Control Points (CCP)

Critical control points in instant ginger drink processing were also determined. The determination was conducted by analysing critical parameters in all steps of processing. Critical parameters analysis was done by identifying the cause and source of quality defects from raw material and all steps in processing. There were also taken into consideration the controlling as well as determination of degree of risk on quality. Critical control points were determined by analysing the cause, source, or justification of critical parameters in all steps of processing including raw material receiving, sortation, weighing, washing, grating, pressing, sedimentation, dissolution, filtration, cooking or crystallization, cooling, and sieving.

Results and Discussions

Size Reduction

Reduction of ginger roots by two different methods resulted insignificant time of reduction as showed in table 1.Method of size reduction does not significantly affect the yield and time. Meanwhile, blending in the larger scale required industrial blender machine. Industrial blender operation for small scale industry is discontinue operation or batch system that will take more time to operate. On the other hand, grating by grating machine in the capacity of 100 kg/h can be operated continuously. Therefore, grating is selected as the method for size reduction. Furthermore, both methods resulted in insignificantly different yield.

According to Zhao[8], the superfine grinding could produce a narrow and uniform particle size distribution in dry ginger. Water absorption index increased significantly with decreasing particle size. It means that particle size of ginger after size reduction influence degree of water solubility thus extractability of ginger components. Zhan *et al.,* isolated 24 compounds previously reported as pungent compounds and 50 volatile compounds from ginger. The volatile compounds were mainly alpha-zingiberene, beta-sesquiphellandrene, alpha-farnesene, beta-bisabolene, alpha-curcumene, which were mostly consisted of sesquiterpene hydrocarbons. The pungent compounds of ginger were mainly 6-gingerol, shogaol, and zingerone produced by the thermal degradation of gingerols or shogaols. The pungency of ginger is due to gingerol, an oily liquid consisting of homologous phenols[10]. Perhaps this compound does not dissolve well in water. However, ginger also contains other components such as 3-6 % fatty oil, 9 % protein, 60-70 % carbohydrates, 3-8 % crude fibre, about 8 % ash, 9-12 % water and 2-3 % volatile oil[10]. Some of these compounds are soluble in water that contributes to the ginger extract in instant ginger drink preparation.

Table 1: The effect of size reduction methods onrequired time and yield

Method of Size Reduction	Required Time	Yield
Grating	7.10±0.11a	166.67±8.42a
Blending	7.36±0.20a	156.67±3.54a

Duration of Sedimentation

Sedimentation is one of processing steps in instant ginger drinks that aims to remove starch from the extract. Starch inhibits the sugar crystallization during cooking and evaporation in instant ginger processing. According to Buera *et al.,*[11], starch inhibits sucrose crystallization. Sugar promotes the formation of glassy matrix. Once crystallization is initiated, sugar molecules become tightly packed, and the amount of water that can be held therefore

decreases, and, in closed containers, water remains in the amorphous phase.

Duration of sedimentation significantly affected the starch concentration in the ginger filtrate (table 2). Increasing sedimentation time reduced starch concentration in the ginger filtrate.

Sedimentation time of 60 and 720 min showed insignificant difference of starch content. Sedimentation of 720 min produced the lowest starch content but it was not different from 60 min. Sedimentation of 10 min showed significant different with 60 min sedimentation but 10 min sedimentation resulted also low starch content in ginger filtrate. We choose 10 min of sedimentation because this treatment produced low enough starch in the filtrate. Also, longer sedimentation time than 10 min sand might increase production cost.

Table 2: The effect of sedimentation time on starch content of ginger extract

Duration of Sedimentation (min)	Starch Content (% wb)
0	57.47±2.1c
10	4.70±0.02b
60	2.50±0.00a
720	2.21±0.00a

Ginger to Sugar Ratio

Ginger to sugar ratio affected the time of cooking for crystallizing the sugar (table 3). The amount of sugar significantly affected time for cooking. Increasing sugar concentration in the ginger extract-sugar mixture solution(juice) reduced cooking time. This ratio affected sugar crystallization in juice cooking. Principally, instant ginger drink preparation is crystallization process that converts juice into sugar crystal during cooking. During cooking, water evaporates meanwhile juice is continuously stirred. Crystallization is a solid–liquid separation process where molecules are transferred from dissolved solute in a liquid phase to a solid phase through two steps: nucleation and crystal growth[12]. Sugar crystallization occurs through the mechanisms of nucleation, growth, and agglomeration[13].The formation of the crystalline phase from supersaturated solutions can occur by either a spontaneous or a forced nucleation mechanism[14]. In this case, spontaneous nucleus occurs during instant ginger drink cooking.

The crystallization in instant ginger drink production is similar with the crystallization in sugar cane processing. The crystallization takes place following three phases. According to Georgieva *et al.,*[13], the first phase is evaporation of juice until supersaturation reaches. At this phase, the seed crystal or nucleus is obtained. Second phase is the growth of the crystal. As water is evaporated, the dissolved sugar concentration increases, resulting in crystal growth. The third phaseconsists of tightening which is principally controlled by evaporationcapacity.

In instant ginger drink production, cooking of the juice (the mixture of ginger extract and cane sugar) is aimed for water evaporation. Cooking is also done with continuous stirring. Agitation of the juice is very important to accelerate mass and energy transfer during crystallization. After nucleus formation, mass transfer of sugar from solution into crystal seed is very important. Transfer of sugar mass into crystal seed needs energy that is facilitated by agitation.

Nucleation occurs when supersaturation is reached due to water evaporation. Supersaturation is also as a critical sugar crystallization parameter[13]. Increasing sugar concentration in the juice shortens time for nucleation because supersaturation condition is faster to achieve. Once seed crystal is formed, nucleus growth simultaneously takes place. In high sugar concentration, the growth of crystal is easier and faster because of higher mass transfer. Therefore, increasing sugar that was added into the ginger extract reduced the cooking time significantly

Table 3: The effect of ginger to sugar ratio on the crystallization time

Ratio of Ginger to Sugar (w:w)	Crystallization Time (min)
1:1.0	31.12±1.21b
1:1.5	34.48±2.01c
1:2.0	45.20±1.45d
1:2.5	25.02±0.86a

Critical Points (CP) and Critical Control Points (CCP)

This study also aimed to determine critical points (CP) and critical control points (CCP) in instant ginger drink production at small scale industry, in this case at UKM DIA as one of small instant ginger drink industries. Determination of CP and CCP is very important quality of finished product. CP and CCP were evaluated based on the processing steps of instant ginger drink, which are raw material receiving, sortation, weighing, washing, grating, pressing, sedimentation, dissolution, filtration, cooking or crystallization, cooling, and sieving. Analysis of CPs and CCPs is shown in table 4.

Table 4: Analysis of critical points and critical control points for instant ginger drink processing

Step of Processing	Causes/Sources/ Justification	Risk (L,M,H)	Degree of Risk (L,M,H)	CP/CCP
Raw material receiving	•Specification of raw materials is not in accordance to the standard			
	•High impurities of ginger roots	M	L	CP
Sortation	Imperfect sortation	L	L	CP
Weighing	-	-	-	CP
Washing	-	-	-	CP
Grating	-	-	-	CP
Pressing	Imperfect pressing	-	M	CP
	Broken equipment	-		
Sedimentation	Imperfect sedimentation (too short or too long)			CP
Blending ginger extract with sugar	-	-	-	CP
Filtration	Broken equipment	L	L	CP
Crystallization	High water content			
	Imperfect crystallization (too short or too long)	M	M	CCP
Cooling	Contamination	M	L	CP
Sieving	Broken equipment, contamination	M	L	CP
Packing	Contamination, imperfect packing	M	L	CP

CP = control point
CCP = critical control point
P = physical hazard
C = chemical hazard
L = low risk
M = medium risk
H = high risk

Raw material receiving is a control point that is very important to check the suitability of raw materials with specification. Main raw materials for instant ginger drink production are ginger root and cane sugar. Ginger roots mentioned were clean and fresh harvested 8-10 month after planting. Sugar cane should be white in colour, dry, and fine grain. Usually, problems in raw material receiving are high impurities of roots that mainly come from soil, premature harvesting, overage, and defects of the roots such as wounds and bruises. According to Bailey-Shaw *et al.,*[15], the content of [6] gingerols was also found to be consistently high (7–9 months) in oleoresin samples. Kiran et al16 reported that ginger

harvested at 9-month maturity had the highest citral and zingiberene. The oleoresin content was found to decrease with maturity in all cultivars. Thus, age of the roots after planting is a critical factor that should be controlled well during receiving.

Sortation is a control point to remove all subgrade roots that characterized by wounds and bruises as well as overage and premature roots. The next steps are weighing, washing, and grating which are also control points. Washing should be well controlled to ensure that all roots are clean to avoid impurities as physical dirt. Mechanical grating is used for size reduction to facilitate extraction of ginger. Continuous grating is employed in this step.

Next step in instant ginger drink production after grating is pressing to leach out the ginger extract. Pressing is a control point that should be well controlled. Control pressure is very important to ensure the uniformity of ginger extract composition. All ginger liquid is expected to leach out in this step, either water soluble or oil soluble compounds from ginger roots. The pungency is produced by non-steam-volatilecomponents, known as thegingerols, which possess a 1-(4′-hydroxy-3′-methoxyphenyl)-5-hydroxyzlkan-3-onestructure[17].

Sedimentation is a control point that should be well done to remove starch. As previously discussed, residual starch in ginger extract will inhibit sugar crystal formation. This step is not a critical control point to food safety, but very important to the quality of final product and the crystallization step. The next step is adding sugar to the ginger extract that should be well controlled to assure that the composition between ginger extract and sugar cane meet the standard. The amount of sugar will affect the time of cooking (crystallization) and aroma and taste of the final product. Increasing sugar reduces crystallization time, but decreases the pungency of the final product.

Filtration is the step after blending ginger extract with sugar and this step is a control point. Filtration by using filter cloth should bewell controlled to assure that no debris contaminates the filtrate. Crystallization is done after filtration. This step takes the longest time during instant ginger drink production and represents a critical control point. Time of crystallization should be well controlled because too short crystallization time will produce clump crystal due to high moisture content. Meanwhile, a too long crystallization time will cause caramelization. According to Purlis[18], caramelization is a complex group of reactions that occurs by heavy heating. Caramelization leads undesirable brownish colour of final instant ginger drink. Meanwhile, short time for crystallization produces wet products that are susceptible to microbial growth and short shelf life.

The next steps after crystallization arecooling, sieving, and packaging. Cooling is aimed to lower the temperature into ambient temperature by letting the product in open container. This step has a risk of environmental contamination and should be well controlled. Cooling process should be conducted in a separated room. Manually sieving is meant to achieve particle size uniformity into 20 mesh. This step is a control point because contamination can occur from workers because in the case of "UKM DIA", sieving is performed manually. Sieve breaking should also be prevented to avoid un-uniformity of final product.

The last step is semi-automatic packaging by using plastic pouch. This is a control point that should be well controlled to prevent contamination from workers and imperfect sealing. Leakage of seal is harmful because of biological contamination from ants and the product will quickly absorb water. Sugar in amorphous state such as in instant ginger drink easily absorbs water due to its high hygroscopicity. Water absorption will lead to high moisture content of the product that is very susceptible to clumping and microbial growth.

Conclusions

Instant ginger drink is a ginger based product considered to be a healthy drink. Critical parameters in instant ginger drink processing are size reduction, sedimentation time, and ratio of ginger to sugar. Control points and critical control point have been established for instant ginger drink production. All steps in instantginger drink processing are control points, except crystallization which is a critical control point.

Conflict of Interest

Authors declare that there is no conflict of interest.

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