

Formula optimization of herbal drink based on coconut sugar and ginger using the Taguchi method

[Optimasi formula minuman herbal berbasis gula merah dan jahe menggunakan metode Taguchi]

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ABSTRACT

Increasingly positive public consumption trends have increased demand for functional products such as ginger sugar herbal drinks. However, Micro, Small, and Medium Enterprises (MSMEs) as producers of ginger sugar herbal drinks, still have production constraints such as relying on recipes that have been passed down from generation to generation with inconsistent processes that have an impact on quality uniformity. The purpose of this study is to redesign the optimal formulation of ginger sugar herbal drinks based on parameters that affect the process. The method used is the Taguchi method with 4 (four) factors and 3 (three) levels with an L9 (34) orthogonal array matrix. Then, quality parameters were tested to determine the best ginger sugar herbal drink Product. The combination of level factors in the optimal formula of ginger sugar herbal drink is the composition of ginger juice 300 mL, brown sugar 700 grams, granulated sugar 500 grams, and cooking time 45 minutes. The results of testing the quality characteristics of the confirmation experiment were following SNI requirements, namely water-insoluble part content 0.84%; water content 4.99%; ash content 1.65%; reducing sugar content 2.48%; sucrose sugar content 81.15%; dissolving time 29.93 seconds; antioxidant activity 67.13 ppm; color sensory properties 5.43; aroma sensory properties 5.32; taste sensory properties 5.16; aftertaste sensory properties 5.53; and overall sensory properties 5.21.

Keywords: Quality, Taguchi Method, Herbal Drink

ABSTRAK

Tren konsumsi masyarakat yang semakin positif menyebabkan permintaan produk fungsional seperti minuman herbal gula jahe terus mengalami peningkatan. Namun, Usaha Mikro, Kecil, dan Menengah (UMKM) sebagai produsen minuman herbal gula jahe, masih memiliki kendala produksi seperti mengandalkan resep yang turun temurun dengan proses yang belum konsisten sehingga berdampak pada ketidakseragaman kualitas. Tujuan dari penelitian ini adalah merancang kembali formulasi yang optimal dari minuman herbal gula jahe berdasarkan parameter yang berpengaruh terhadap proses. Metode yang digunakan adalah metode Taguchi dengan 4 (empat) faktor dan 3 (tiga) level dengan matriks orthogonal array L₉ (3⁴). Kemudian dilakukan pengujian parameter mutu untuk menentukan produk minuman herbal gula jahe terbaik. Kombinasi faktor level pada formula optimal minuman herbal gula jahe adalah komposisi sari jahe 300 mL, gula merah 700 gram, gula pasir 500 gram, dan waktu pemasakan 45 menit. Hasil pengujian karakteristik mutu eksperimen konfirmasi sudah sesuai dengan syarat SNI yaitu kadar bagian tak larut air 0,84%; kadar air 4,99%; kadar abu 1,65%; kadar gula pereduksi 2,48%; kadar gula sukrosa 81,15%; waktu larut 29,93 detik; aktivitas antioksidan 67,13 ppm; sifat sensori warna 5,43; sifat sensori aroma 5,32; sifat sensori rasa 5,16; sifat sensori aftertaste 5,53; dan sifat sensori overall 5,21.

Kata kunci: Kualitas, Metode Taguchi, Minuman Herbal

Introduction

Spices have long been an important part, not only as food flavoring but also as raw materials for cosmetic, pharmacological, and food and beverage. Ginger is among the popular spices used as a superior

commodity (*Zingiber officinale*). According to data from the Central Bureau of Statistics (2023), ginger is a commodity that has the largest productivity figures when compared to other biopharma plants, which amounted to 247,455,487 kg with a land area of 104,093,877 m². In addition, this biopharma plant has ingredients that are beneficial for health. Important components found in ginger are gingerol, shogaol, zingerone, resin, and essential oil (Garza-Cadena et al., 2023; Shukla et al., 2019). Because of the content of these components, ginger is utilized for various types of treatment such as antioxidants, anti-inflammatory, antimicrobial, and so on (Baptista et al., 2022).

Demand for functional food products and foods that contain benefits for the body such as herbal drinks continues to increase (Chaisuwan & Supawong, 2022). One popular herbal drink is ginger sugar herbal drink, which is a unique blend of ginger, sugar, and other spices. Brown sugar as a natural sweetener that does not add any additives in its processing is the choice of sweetener for ginger sugar herbal drinks. In addition, brown sugar is quite abundant, as evidenced by Indonesia's ability to become a major exporter of palm sugar. In 2020, the number of palm sugar exports was 39,400 tons with a value of USD 63.5 million (Ministry of Industry of the Republic of Indonesia, 2022).

The utilization of brown sugar to sweeten instant ginger drinks has been studied by Syamsul et al. (2023), who found the best ratio of ginger and palm sugar was 150:350 g/g. In comparison (Okwunodulu et al., 2023) formulated a functional drink with ginger, garlic, turmeric, and pineapple. A formula with a 70% ginger composition was found to have the highest acceptability. These studies prove that ginger and brown sugar-based drinks have flavors, aromas, and colors that are highly preferred by consumers, so they have great potential to be developed into commercial herbal beverage products in the form of ginger sugar herbal drinks. This product is starting to be widely produced by the community in Micro, Small, and Medium Enterprises, such as the Natural Ginger Sugar MSMEs in Purworejo Regency.

However, there are still challenges that need to be resolved. Based on a preliminary survey, in their production practices, MSMEs still rely on hereditary recipes and processes that are not consistent, so they have not been able to produce uniform products. This is because MSMEs often rely on estimates and instincts in processing ginger sugar herbal drink products. Among them are mixing the composition of the product with an uncertain dose and using instinct to assess the maturity of the ginger sugar product before molding. To produce uniform and quality products, the composition and production process must be consistent. This is what needs to be evaluated, so further research is needed to obtain an optimal formulation design and production process so that it can be adopted by producers.

This study aims to improve the quality of ginger sugar herbal drinks by homogenizing the product quality and improving the production process. The Taguchi method can be applied to this problem because it aims to optimize the quality of the product and the process to minimize costs and reduce resources to a minimum (Aseibichin et al., 2024) optimized the transesterification of *Jatropha* oil into fatty acid methyl ester using Taguchi and Response Surface Method (RSM).

The results show that the application of the Taguchi method is considered more cost-effective than RSM because it only requires fewer resources. According to Wang and Zhang (2024), another advantage of this well-known method in quality engineering is that it is effective for optimization involving many parameters while reducing the impact of confounding factors and making it easier to determine the appropriate combination of parameters. By the Taguchi method, the quality of ginger sugar herbal drinks is expected to be improved by the optimal factors and levels.

Material and Method

Material and equipment

The main ingredients required are coconut brown sugar, ginger emprit, granulated sugar, and spices. In comparison, the materials needed for quality parameter analysis include distilled water, methanol (Merck), DPPH (Sigma Aldrich), NaOH (Merck), HCl (Merck), H₂SO₄ (Merck), KI (Merck), sodium thiosulfate

(Merck), starch indicator (Merck), phenolphthalin (Merck), lead acetate (Merck), ammonium hydrogen phosphate (Merck), sodium carbonate (Merck), citric acid (Merck), and copper sulfate pentahydrate (Merck). Analysis equipment included glassware, oven (Memmert UNB 400), furnace (Furnace Carbolite Gero CWF 11/5), and uv-vis spectrophotometer (Thermo Scientific Genesys 10s).

Selection of experimental levels and factors

The selection of parameters for the optimization of ginger sugar herbal drinks was obtained based on the results of observations and discussions with MSMEs and literature studies. Based on this, 4 (four) factors and 3 (three) treatment levels were selected for the optimization of the ginger sugar herbal drink shown in following Table 1.

Table 1. Factors and treatment levels

No	Factor	Level		
		1	2	3
A	Ginger juice (mL)	200	300	400
B	Brown sugar (gram)	700	500	300
C	Granulated sugar (gram)	300	500	700
D	Cooking time (minutes)	45	60	75

Determination of free degree and orthogonal matrix

Based on the calculation, it is known that the total free degree is 8, so the selection of an orthogonal array matrix that is close to the free degree is L9 (3⁴).

Plotting levels and factors in the orthogonal matrix

According to Table 1, the most appropriate orthogonal array matrix for the Taguchi method design is L9 (3⁴), with the experimental setup detailed in Table 2.

Table 2. Experimental design of the study

Eksperimen	Factor			
	A	B	C	D
I	A1	B1	C1	D1
II	A1	B2	C2	D2
III	A1	B3	C3	D3
IV	A2	B1	C2	D3
V	A2	B2	C3	D1
VI	A2	B3	C1	D2
VII	A3	B1	C3	D2
VIII	A3	B2	C1	D3
IX	A3	B3	C2	D1

Product concept experiment

The product manufacturing stage begins with melting coconut brown sugar and granulated sugar until boiling, then adding ginger extract and spice extract to the pan. During cooking, the mixture is stirred continuously so that there are no lumps at the bottom of the pan and it does not burn. Once it reaches the appropriate consistency, the mixture is cooled and then molded. Once hardened, the ginger sugar is ready to be removed from the mold, cooled to room temperature, and packaged.

Quality parameter testing

Tests were conducted to determine the best ginger sugar herbal drink product. All analyses were conducted with three replicates. The observed parameters of this product include 1. Water insoluble part content (BSN, 1992a). A 20-gram sample was dissolved in 200 ml of hot water, filtered with filter paper, then reheated at 105°C for 2 hours, cooled in a desiccator, and weighed. Moisture content (AOAC, 2005). A

5-gram sample was weighed in a cup that had been dried, cooled in a desiccator, and weighed until constant weight. 2. Ash content (AOAC, 2005). Several samples were burned on a hot plate and placed in a furnace at 500-600°C for 6 hours, cooled, and weighed. 3. Reducing sugar content (BSN, 1992b). Dissolve the sample in distilled water, and add 25 ml of Luff-Schoorl solution. Heat the mixture for 10 minutes, cool, add 10 ml of Fehling A and Fehling B solutions, then titrate with standard $\text{Na}_2\text{S}_2\text{O}_3$. 4. Sucrose sugar content (BSN, 1992b). A total of 50 ml of filtrate in the determination of reducing sugar is mixed with 25 ml of 25% HCl, heated, cooled, neutralized with 30% NaOH, and added distilled water to the mark. After going through a series of additional processes and titration with 0.1 N Na-thiosulfate. 5. Sensory properties (Radu et al., 2024). This test assesses panelist acceptance of the color, taste, aroma, aftertaste, and texture of the sample with 30 panelists using a 7-point hedonic scale. 6. Dissolving time (Pamangin et al., 2020). A total of 5 g of sample plus 25 ml of water at 30°C, stirred, and recorded the dissolution time. Antioxidant activity (DPPH), (Wei et al., 2024). The sample was dissolved and diluted at several concentrations, then measured the absorbance at 517 nm to calculate the % inhibition and IC50 value through linear regression.

Data analysis

To obtain production process parameters based on the Taguchi concept, data processing, and analysis were carried out with Minitab Statistical Software version 21.2, which includes data processing of mean average and S/N ratio to obtain the contribution of influential factors in each experiment. The values of physicochemical and sensory characteristics of ginger sugar herbal drinks were calculated based on the appropriate S/N ratio type. The Smaller the better S/N ratio type means that smaller values have better quality, such as the parameters of water-insoluble part content; water content; ash content; reducing sugar content; antioxidant activity; and dissolving time, which are calculated according to equation (1). While the Larger the better type of S/N ratio means that the larger the value the better, such as the parameters of sucrose sugar content and sensory properties, which are calculated according to equation (2).

S/N Smaller the better

$$\eta = -10 \log \left(\frac{1}{n} \sum_{i=1}^n y_i^2 \right) \quad (1)$$

S/N Larger the better

$$\eta = -10 \log \left(\frac{1}{n} \sum_{i=1}^n \frac{1}{y_i^2} \right) \quad (2)$$

Description:

η = S/N ratio value

n = number of replicates

y = value of each experiment

(1) Determination of optimal concept recommendations

Calculation of optimal concept recommendations on ginger sugar herbal drink products using the Multi Response Performance Index (MRPI) calculation (Moganapriya et al., 2022). The initial step of this stage is to calculate the weight using equation (3) for the Smaller the better characteristic and equation (4) for the Larger the better characteristic. Then calculate the MRPI value using equation (5).

MPRI Smaller the better

$$W_{ij} = \frac{1/\eta_{ij}}{\sum 1/\eta_j} \quad (3)$$

MPRI Larger the better

$$W_{ij} = \frac{\eta_{ij}}{\sum \eta_j} \quad (4)$$

Calculation of total MPRI value

$$(MRPI)_i = W_1 \eta_{i1} + W_2 \eta_{i2} + \dots + W_j \eta_{ij} \quad (5)$$

W = the weight of each experiment

(2) Confirmation

In this study, confirmatory experiments were performed to validate the conclusions drawn during the analysis phase (Awwaliyah et al., 2020) and to test combinations of factors and levels. The results of the confirmation experiment must be within the confidence interval of the optimal conditions (6). The confidence interval for the confirmation experiment is calculated based on equation (7).

Optimal condition confidence interval

$$Cl_{mean} = \pm \sqrt{F_{\alpha;v1;v2} \times MS_e \times \frac{1}{n_{eff}}} \quad (6)$$

Confidence interval of confirmation experiment

$$Cl_{mean} = \pm \sqrt{F_{\alpha;v1;v2} \times MS_e \times \left(\frac{1}{n_{eff}} + \frac{1}{r} \right)} \quad (7)$$

CI = Confidence interval

$F_{\alpha;v1;v2}$ = F-ratio value from table

MS_e = Mean sum of polled error squares

r = Number of observations used to calculate the mean

Results and discussion

Product description

The optimized product is a beverage made from sugar and ginger, in the form of a hemispherical solid with a diameter of ± 5 cm. The product color is brown typical of brown sugar with a weight of about 40 grams. The product is designed to be ready to brew, where each piece can be brewed for one glass of drink. The prototype of the ginger sugar herbal drink can be seen in Figure 1. To evaluate the highest quality of the ginger sugar herbal drink, tests were carried out focusing on both physical and chemical properties. The results of these tests are presented in detail in Table 3.



Figure 1. Ginger sugar herbal drink product prototype

Table 3. Physicochemical quality of ginger sugar herbal drink

Experiment	Water insoluble part (%)	Water content (% wt)	Ash content (%)	Reducing sugar content (%)	Sucrose content (%)	Dissolving time (s)	Antioxidant activity (ppm)
I	0.79 $\pm$ 0.06	6.21 $\pm$ 1.85	2.27 $\pm$ 0.17	2.81 $\pm$ 0.45	76.65 $\pm$ 1.52	32.33 $\pm$ 2.52	95.28 $\pm$ 1.20
II	0.83 $\pm$ 0.10	6.49 $\pm$ 0.25	2.14 $\pm$ 0.21	2.67 $\pm$ 0.32	81.77 $\pm$ 1.67	24.00 $\pm$ 2.65	88.28 $\pm$ 0.76
III	0.82 $\pm$ 0.07	4.15 $\pm$ 0.87	1.14 $\pm$ 0.03	2.47 $\pm$ 0.33	82.80 $\pm$ 1.94	31.33 $\pm$ 1.53	85.67 $\pm$ 2.03
IV	0.89 $\pm$ 0.02	5.55 $\pm$ 0.07	2.26 $\pm$ 0.22	3.02 $\pm$ 0.26	81.97 $\pm$ 1.47	38.00 $\pm$ 1.00	70.77 $\pm$ 1.10
V	0.85 $\pm$ 0.06	3.49 $\pm$ 0.13	1.99 $\pm$ 0.10	2.68 $\pm$ 0.04	83.42 $\pm$ 0.98	34.00 $\pm$ 4.00	71.27 $\pm$ 1.00
VI	0.85 $\pm$ 0.03	6.22 $\pm$ 0.94	1.26 $\pm$ 0.06	2.23 $\pm$ 0.31	74.18 $\pm$ 0.99	23.67 $\pm$ 3.21	62.38 $\pm$ 0.16
VII	0.89 $\pm$ 0.02	7.94 $\pm$ 0.48	2.15 $\pm$ 0.09	3.12 $\pm$ 0.32	84.37 $\pm$ 0.53	51.33 $\pm$ 3.79	103.08 $\pm$ 1.85
VIII	0.85 $\pm$ 0.15	4.97 $\pm$ 1.22	1.29 $\pm$ 0.03	2.65 $\pm$ 0.20	75.14 $\pm$ 1.47	32.00 $\pm$ 3.61	54.25 $\pm$ 0.46
IX	0.83 $\pm$ 0.03	5.44 $\pm$ 0.40	2.05 $\pm$ 0.10	2.34 $\pm$ 0.31	79.34 $\pm$ 1.57	26.67 $\pm$ 5.13	59.20 $\pm$ 0.33

Water insoluble part content

The quality characteristic of water-insoluble parts is **S/N Smaller the Better**. This test is needed to determine how much dirt or other substances are dissolved in the product (BSN, 1992). Based on the research results presented in Table 3, the average value of the experiments ranged from 0.79 - 0.89%. The lowest water-insoluble part content was in experiment I and the highest was in experiment VII. Based on Figure 2, the ginger juice factor had the greatest influence on the average value of the water-insoluble part. This is due to the small flakes of ginger pulp that are still carried in the ginger juice. Sediment in ginger sugar herbal drinks will be formed from water-insoluble ginger components (Mayani et al., 2014).

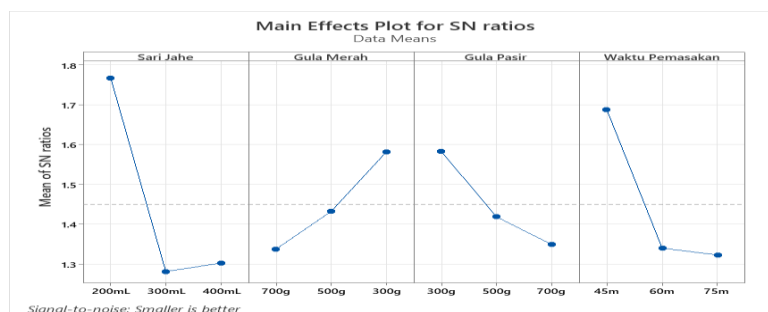


Figure 2. Response graph of S/N ratio factor effect for water-insoluble part.

Water content

The moisture content parameter in the product needs to be considered because it affects texture, hardness, and shelf life (Yuwana et al., 2022). The quality of moisture content is calculated with S/N Smaller the Better. Based on the research results presented in Table 3, the average water content of ginger sugar herbal drinks ranged from 3.49 - 7.94%. The highest water content was found in experiment VII and the lowest was found in experiment V. Based on Figure 3, the treatment of different cooking times is a factor that affects the moisture content of the product due to the evaporation process (Andika et al., 2022).

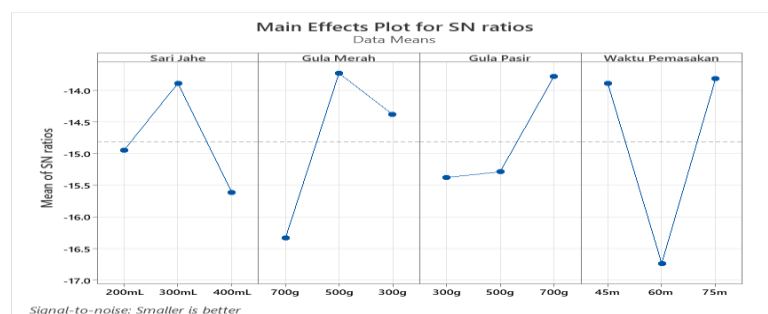


Figure 3. Response graph of the effect of the S/N ratio value factor for moisture content

Ash content

Ash content is one of the quality parameters that shows food safety indicators as a determinant of the level of metal contamination in food ingredients. The quality characteristic of ash content in this study is S/N Smaller the Better. Based on the results presented in Table 3, the average ash content of the products produced was 1.14 - 2.27%. This result is still higher than the research conducted by Amelia et al. (2021) who obtained an ash content of 0.11 - 0.67% with ginger tempeh juice beverage products. This is due to the addition of more brown sugar in the ginger sugar herbal drink product. The highest ash content was in experiment I and the lowest was in experiment III. Based on Figure 4, brown sugar is a factor that affects ash content, due to the large amount of minerals in the raw material.

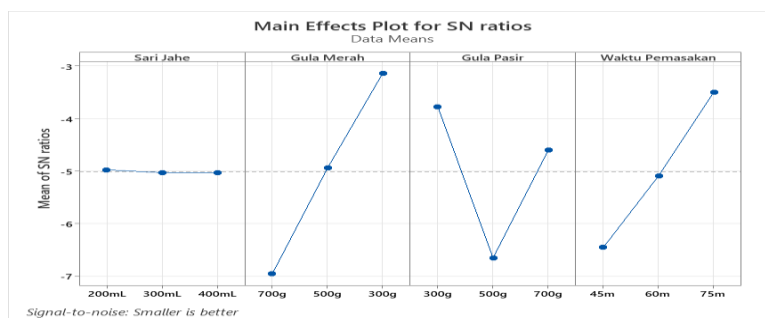


Figure 4. Response graph of the effect of the S/N ratio value factor for ash content

Reducing sugar content

The value of reducing sugar content is calculated with the smaller the better S/N ratio. The average value of the reducing sugar response ranged from 2.34 - 3.12% (Table 3). The highest reduction sugar content was in experiment VII and the lowest was in experiment VI. Based on Figure 5, the factor that showed the greatest response effect was the brown sugar factor. Brown sugar and granulated sugar have significant differences in terms of processing and chemical composition, which affects the reducing sugar content in them. Brown sugar contains high levels of reducing sugars such as glucose and fructose as well as natural components such as minerals and vitamins. In contrast, granulated sugar consists almost entirely of sucrose, a non-reducing disaccharide (Rahman et al., 2023; Tanjung et al., 2018).

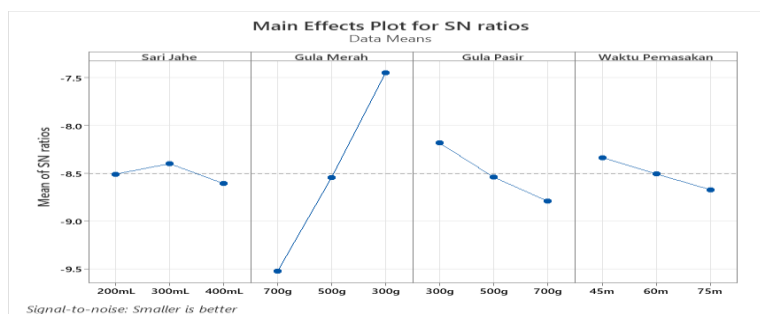


Figure 5. Response graph of the effect of the S/N ratio value factor for reducing sugar content

Sucrose sugar content

The quality parameter characteristic of sucrose content in this study is S/N Larger the better. Based on the results presented in Table 3, the average value of sucrose content is 74.18 - 84.37%. The highest sucrose sugar content was in experiment VII, while the lowest was in experiment VI. Based on Figure 6, the granulated sugar composition factor is the most influential on the quality parameters of the sucrose content of ginger sugar herbal drinks, due to the high sucrose content of granulated sugar, which is up to 97.1% (Spanenberg et al., 2019). Sucrose is a type of sugar that tends to crystallize, so the sucrose content in the product affects the physical shape and texture. The higher the sucrose content, the denser the shape of the product. Conversely, monosaccharides (glucose and fructose) tend to be difficult to crystallize, making the product soft quickly (Harjanti et al., 2024).

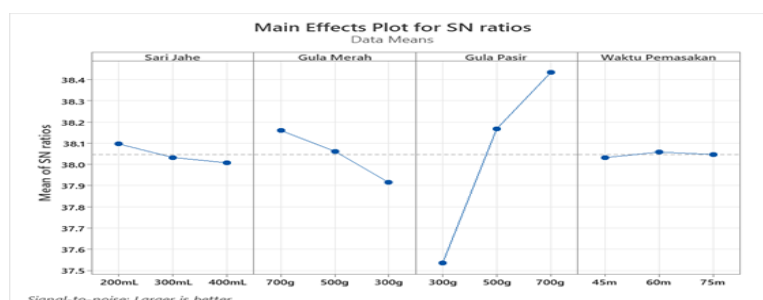


Figure 6. Response graph of the factor effect of S/N ratio value for sucrose sugar content

Dissolving time

The smaller the better S/N characteristic was used to calculate the results of the dissolving time. Based on the results presented in Table 3, the average dissolving time of ginger sugar herbal drink produced ranged from 23.67 - 51.33 seconds with the highest dissolving time was experiment VII and the lowest was experiment VI. These results indicate that the dissolving time of ginger sugar herbal drink is not more than 1 minute. Based on Figure 7, the most influential production process factor for dissolving time-based on Figure 7 is the brown sugar factor. The addition of sugar is one of the efforts so that the product can dissolve in a faster time (Tanjung et al., 2018).

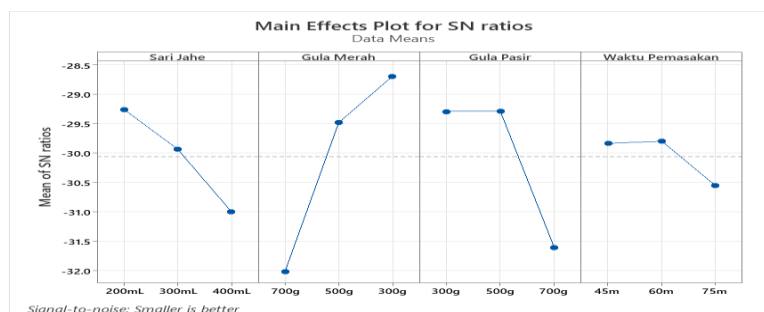


Figure 7. Response graph of the effect of the S/N ratio value factor for dissolving time

Antioxidant activity (IC50)

Antioxidant activity (IC50) in this study is a number of antioxidant compounds to reduce the activity of DPPH radicals by 50%, the smaller the IC50 value, the stronger the antioxidant compounds contained in the material. Thus, the quality value characteristic of the S/N ratio of antioxidant activity is Smaller the Better. Based on the results, the average value of the experiment ranged from 54.25 - 103.08 ppm (Table 3). These results indicate that the products have strong (50 - 100 ppm) to moderate (100 - 150 ppm) antioxidants (Wibawa & Saraswaty, 2023). The formula with the strongest antioxidant category was shown in experiment VIII and the weakest was experiment VII. Based on Figure 8, the ginger juice factor has the greatest influence on the antioxidant activity value, per the properties of ginger as a free radical antidote (Baptista et al., 2022).

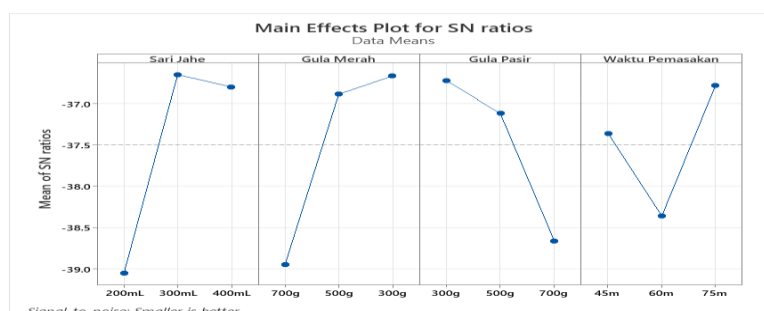


Figure 8. Response graph of the effect of the S/N ratio value factor for antioxidant activity

Sensory properties

The purpose of sensory testing is to determine the assessment and consumer acceptance of the product using a hedonic test with a scoring system (Prayitno et al., 2023). The characteristic S/N ratio quality value of all attributes is Larger the Better. The test results can be seen in Table 4.

Color is a visualization that is immediately visible from a product compared to other variables so it plays an important role in consumer attractiveness (Khalisa et al., 2021). Based on the research results in Table 4, the average value of the experiments ranged from 3.70 - to 5.67 from a maximum value of 7. The color attribute that panelists liked the most was experiment VIII and the least preferred was experiment IX.

Table 4. Sensory quality of ginger sugar herbal drink

Experiment	Color	Aroma	Taste	Aftertaste	Overall
I	5.50 ± 0.36	4.57 ± 0.06	5.30 ± 0.62	4.80 ± 0.70	5.30 ± 0.44
II	5.43 ± 0.21	4.57 ± 0.12	4.57 ± 0.21	4.83 ± 0.67	4.60 ± 0.30
III	4.73 ± 0.15	5.00 ± 0.40	4.43 ± 0.31	4.20 ± 0.20	4.53 ± 0.42
IV	5.50 ± 0.62	4.53 ± 0.23	5.37 ± 0.75	5.53 ± 0.23	5.23 ± 0.40
V	5.60 ± 0.44	4.83 ± 0.31	5.27 ± 0.46	5.10 ± 0.20	5.33 ± 0.25
VI	4.03 ± 0.32	5.00 ± 0.35	5.13 ± 0.76	5.40 ± 0.36	5.30 ± 0.52
VII	5.40 ± 0.30	5.57 ± 0.21	3.77 ± 0.38	3.97 ± 0.57	4.07 ± 0.35
VIII	5.67 ± 0.32	5.00 ± 0.36	3.57 ± 0.93	3.60 ± 0.89	4.07 ± 0.85
IX	3.70 ± 0.69	5.10 ± 0.36	4.63 ± 0.90	4.60 ± 0.87	4.83 ± 0.83

Based on Figure 9, the results showed that the brown sugar factor had the greatest influence on the attribute value. This indicates that the intense brown color typical of brown sugar is more attractive than a fainter brown color (Syamsul et al., 2023; Dusun et al., 2020).

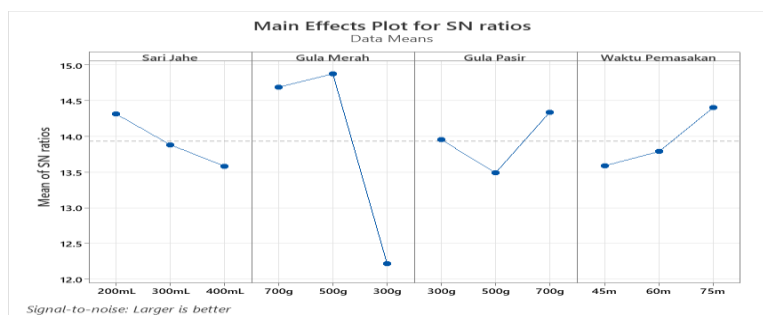


Figure 9. Response graph of the effect of the S / N ratio factor for color

The aroma released by food can stimulate the sense of smell and stimulate appetite (Marantika et al., 2024). Based on the research results presented in Table 4, the average value for aroma attributes ranges from 4.53 - 5.57. The highest aroma value was in experiment VII, while the lowest was in experiment IV. Based on Figure 10, the granulated sugar factor is the most influential factor on aroma attributes, because the addition of granulated sugar makes the aroma of brown sugar and ginger more balanced and less pungent (Syamsul et al., 2023).

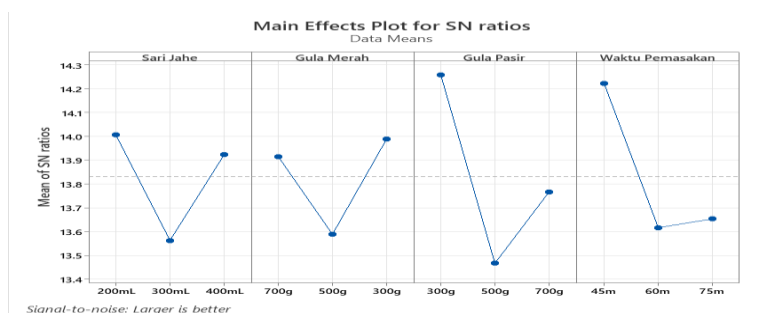


Figure 10. Response graph of the effect of the S/N ratio value factor for aroma attributes

Taste is influenced by several factors including compound, temperature, concentration, and interaction with other flavor components. Therefore, this trait is closely related to aroma (Khalisa et al., 2021). Based on the research results presented in Table 4, the average value of the experiments ranged from 3.57 - 5.30.

The highest value was in experiment VI, while the lowest was in experiment VIII. Based on Figure 11, the ginger juice factor has the greatest influence on the average value. This is due to the presence of gingerol compounds that characterize the taste of ginger (Shukla et al., 2019). According to Syamsul et al. (2023), the flavor of ginger drinks is formed from the raw materials and the cooking process.

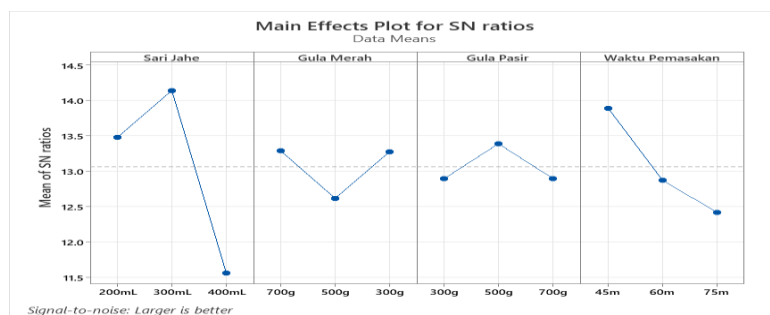


Figure 11. Response graph of S/N ratio factor effect for taste attribute

The aftertaste is the flavor that remains after consuming a product (Rosalinda et al., 2021). Based on the research results presented in Table 4, the average response of the aftertaste attribute ranges from 3.60 - 5.53. The highest value is in experiment IV, while the lowest is in experiment VIII. Based on Figure 12, the ginger juice composition factor is the most influential on the aftertaste attribute of ginger sugar herbal drink, because the addition of ginger leaves a spicy and slightly bitter taste in the mouth. This is due to the presence of oleoresin with gingerol, shogaol, zingerone, oleoresin, and essential oils in ginger (Garza-Cadena et al., 2023; Baptista et al., 2022).

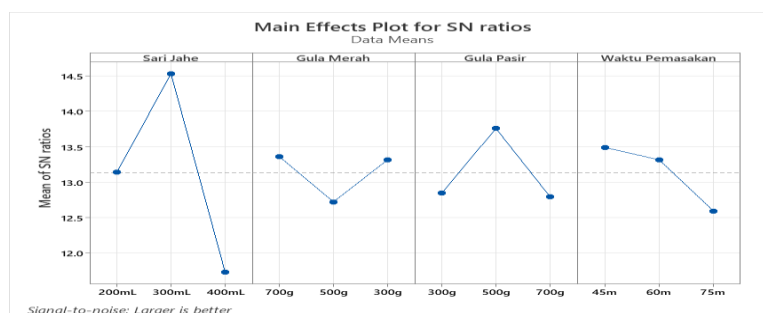


Figure 12. Response graph of S/N ratio factor effect for aftertaste attribute

The overall attribute in sensory evaluation refers to the overall assessment of a product based on all aspects of color, taste, aroma, and aftertaste. This is the final impression produced after considering all sensory elements (Khalisa et al., 2021). Based on the research results presented in Table 4, the average overall attribute value of the ginger sugar herbal drink produced ranged from 4.07 - 5.33 with the highest value being experiment V and the lowest being experiment VII. Based on Figure 13, the influential factor is the ginger juice factor. The combination of all sensory attributes will produce an overall assessment of the panelists who are influenced by all the factors involved in the ginger sugar herbal drink product (Syamsul et al., 2023).

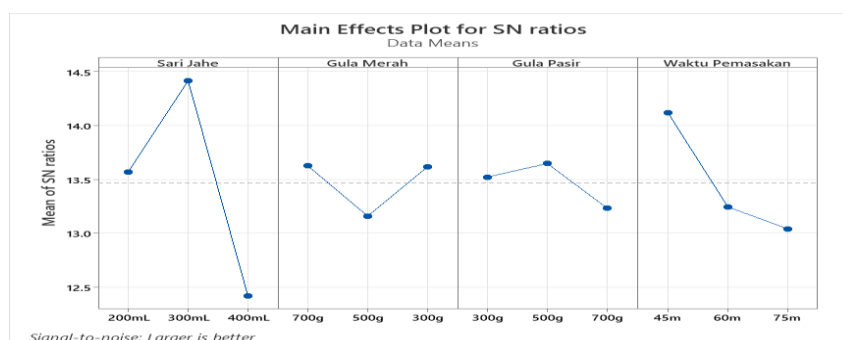


Figure 13. Response graph of factor effect S/N ratio value for the overall attribute

Optimal formula

The S/N ratio value of each response is used to determine the weight of each factor, which is then converted into the MRPI value (Moganapriya et al., 2022). A value is carried out after obtaining MRPI as a single response for ginger sugar herbal drink products. Since MRPI represents a weighted score for each concept, it is necessary to analyze the level of design factors having the highest value to obtain the best product concept. Based on Table 5, the optimal formula obtained from the Taguchi method experimental design in this study is a combination of 300 mL ginger juice, 700 grams brown sugar, 500 grams granulated sugar, and a cooking time of 45 minutes.

Table 5. MRPI value analysis results

No	Factor	Level			MRPI Value		
		1	2	3			
A	Ginger juice (mL)	200	300	400	5.234	6.636	1.871
B	Brown sugar (gram)	700	500	300	5.612	4.335	3.795
C	Granulated sugar (gram)	300	500	700	4.374	4.844	4.524
D	Cooking time (minutes)	45	60	75	5.813	4.165	3.763

Confirmation experiment

A confirmation test was conducted to determine whether the selected conditions could produce a product with the best quality attributes (Awwaliyah et al., 2020). This test is based on a reassessment of product quality. Based on Table 6, the results show that the confirmation test yielded all quality parameters within the confidence interval. This indicates that the product prototype's quality has been confirmed.

Table 6. Confidence interval calculation results

No	Parameter	Confidence Interval	Confidence Interval Value	Upper Limit	Lower Limit	Remarks
1	Insoluble Matter Content (%)	Optimal	0.82 ± 0.03	0.79	0.85	Confirmed
		Confirmation	0.84 ± 0.07	0.77	0.91	
2	Moisture Content (%)	Optimal	5.04 ± 1.23	3.81	6.27	Confirmed
		Confirmation	4.99 ± 1.48	3.51	6.47	
3	Ash Content (%)	Optimal	1.62 ± 0.11	1.51	1.73	Confirmed
		Confirmation	1.65 ± 0.16	1.49	1.81	
4	Reducing Sugar Content (%)	Optimal	2.54 ± 0.32	2.22	2.86	Confirmed
		Confirmation	2.48 ± 0.43	2.05	2.91	
5	Sucrose Content (%)	Optimal	81.26 ± 3.15	78.11	84.41	Confirmed
		Confirmation	81.15 ± 3.42	77.73	84.57	
6	Dissolution Time (s)	Optimal	29.19 ± 6.52	22.67	35.71	Confirmed
		Confirmation	29.92 ± 7.21	22.71	37.13	
7	Antioxidant Activity (IC50) (ppm)	Optimal	69.52 ± 2.58	66.94	72.1	Confirmed
		Confirmation	67.13 ± 2.80	64.33	69.93	
8	Sensory Attribute - Color	Optimal	5.33 ± 0.56	4.77	5.89	Confirmed
		Confirmation	5.43 ± 0.69	4.74	6.12	
9	Sensory Attribute - Aroma	Optimal	5.11 ± 0.39	4.72	5.5	Confirmed
		Confirmation	5.33 ± 0.47	4.39	6.27	
10	Sensory Attribute - Taste	Optimal	4.95 ± 0.84	4.11	5.79	Confirmed
		Confirmation	5.15 ± 1.03	4.12	6.18	
11	Sensory Attribute – Aftertaste	Optimal	4.98 ± 0.77	4.21	5.75	Confirmed
		Confirmation	5.53 ± 0.94	4.59	6.47	
12	Sensory Attribute - Overall	Optimal	5.06 ± 2.01	3.05	7.07	Confirmed
		Confirmation	5.20 ± 0.86	4.34	6.06	

Conclusion

The optimal formula for the ginger sugar herbal drink is a combination of 300 mL ginger juice, 700 grams brown sugar, 500 grams granulated sugar, and a cooking time of 45 minutes. The results of the confirmation experiment's characteristic tests comply with the SNI (Indonesian National Standard) requirements: insoluble matter content 0.84%; moisture content 4.99%; ash content 1.65%; reducing sugar content 2.48%; sucrose content 81.15%; dissolution time 29.93 seconds; antioxidant activity 67.13 ppm; sensory attributes—color 5.43, aroma 5.32, taste 5.16, aftertaste 5.53, and overall 5.21.

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