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Sensory Evaluation of Carbonated *Soykunun-Zaki* Beverage Using Response Surface Analysis

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Abstract: Carbonated*Soykunun-zaki* is a modern adaptation of the traditional *kunun-zaki*, a beverage made from fermented sorghum or millet, water, and other ingredients. This carbonated version aims to appeal to a wider range of consumers by introducing carbonation, stabilizers, and preservatives. In order to optimize the production and enhance the sensory appeal of carbonated *Soykunun-zaki*, this study applies response surface analysis to evaluate various factors such as volume of sample, stabilizer concentration, preservative concentration, and volume of carbon dioxide. The study identified optimal production parameters for a beverage with enhanced sensory characteristics and overall consumer acceptance. Adequate and significant ($p<0.05$) regression models describing the effects of production conditions on the sensory qualities with Lack of fit, F-values obtained showing the models that can be used to navigate the design space were reported. Results obtained showed that the sensory panelist's scores ranged between 6.00 and 7.00 for taste, 5.77 and 6.90 for color, 6.00 and 7.50 for mouthfeel, 5.71 and 8.00 for consistency, 5.88 and 7.65 for aroma and 6.02 and 6.97 for overall acceptability. In all samples analysis of variance showed that preservative concentration, volume of CO_2 injected in samples, and interactions between volume of sample and stabilizer concentration had significant effects on the taste, while the color was significantly affected by the preservative concentration, and interactions between volume of sample and volume of CO_2 injected. Mouthfeel, aroma, consistency and overall acceptance were all significantly affected by the stabilizer concentration. The study identified optimal conditions based on desirability concept indicated that 287.242ml for volume of sample, 1.639% for stabilizer concentration, 0.100% for preservative concentration and 2.500g/L of CO_2 for balancing various factors will produce a beverage with enhanced sensory attributes and overall consumer satisfaction.

Keywords:*production, stabilizer, response surface, beverages, carbonation*

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1. Introduction

Kunun-zaki is a popular beverage in West Africa, traditionally made from fermented sorghum or millet, water, and sweetener [1]. It has long been customary to add more ingredients to fermented beverages made from cereal in order to increase the beverage's overall quality in terms of nutrition and sensory appeal [2] Some of these ingredients include sweet potato, vitamins, spices and legumes [2,3,4]. The methodof enriching cereal beverages with soybeans has been established, and the nutritional profile of *Kunun-zaki*was further improved by including this legume [5]. The beverage known as *Soykunun-zaki* originated from this approach.

Soykunun-zaki is a variant of the *Kunun-zaki* which was developed from fermented millet and addition of soymilk. Soymilk is derived from soybeans and is a rich source of protein, vitamins, and minerals. By incorporating soymilk into *Kunun-zaki*, the nutrient density is increased making it an even more nutrient-dense beverageofchoice [6]. The *Soykunun-zaki*has been the subject of fruitful study by a number of previous researchers, with encouraging outcomes [7,8,9,10].

There is currently a trend toward local food products becoming more modernized. Common trends in the beverage business are variations in ingredients, flavors, production techniques, and cultural influences when compared to locally accessible beverages. Aside from the long shelf life, consistent sensory quality, adequate availability, affordability, and regulatory compliance, local non-alcoholic beverages offer a taste of regional identity and craftsmanship that reflects the rich variety of local culture and tradition. However, there is a gap in the market for these attributes and as consumer preferences continue to evolve, local beverage manufacturers may use innovation to take advantage of new developments and maintain their competitiveness. These characteristics have made carbonated soft drinks more popular amongst consumers. However, as a traditionally non-carbonated beverage, *Kunun-zaki* has largely been overshadowed in the market by the carbonated soft drinks. To meet the demands of health-conscious consumers who prefer low-calorie healthy beverages, attempts have been made to modify this traditionally non-carbonated beverage into a carbonated one using various technique. In spite of remarkable changes in beverages after carbonation, there have been limited studies regarding the effects of carbonation on local beverages.

Carbonation is the process of adding carbon dioxide (CO_2) to drinks, and it has been shown to significantly alter the drinks' sensory qualities. Furthermore, it is well known that carbonation in soft drinks inhibits the growth of microorganisms, prolonging the drinks' shelf life [11]. As a result, by including carbonation and making other changes, the beverage can now appeal to a wider range of consumers worldwide. However, the addition of carbon dioxide, stabilizers, and preservatives can influence the sensory attributes of the beverage, including taste, aroma, texture and its overall acceptance.

Sensory evaluation is critical to understanding consumer preferences and optimizing the production process. Response surface analysis is a statistical approach that allows the study of multiple factors affecting a product's quality. In this study, we used response surface analysis to assess the sensory attributes of carbonated *Soykunun-zaki*, aiming to optimize production conditions for enhanced sensory appeal.

2. Materials and Methods

Materials

Samples of all ingredients: soybeans (*Glycine max*), pearl millet (*Pennisetumtyphodeum*), ginger (*Zingiberofficinale*) and clove (*Eugenia caryopyllata*) were sourced from Kure Ultra-modern Market Minna, Niger State, Nigeria. Production and evaluation of the samples used for experimentation was carried out under strict and standard conditions in the Food Science and Technology Laboratory of the Federal University of Technology, Minna, Nigeria.

Sample preparation

Figure 1. depicts the production process of soykununzaki. The procedure is to soak the millet, soybeans, and spices (ginger and cloves) ground them into a paste, boil the paste with water, andfilter. Then components like sugar, stabilizers, and preservativesare added. After cooling to a very low temperature and being bottled, carbonation comes next.

The system of injecting Carbon dioxide (CO_2) into the beverages was developed by using a modified CO_2 Cylinder coupled with a tube, regulators and pressure gauges as described by [11].

Experimental Design

A central composite design was used to assess the effects of four independent variables: volume of sample, stabilizer (xanthan gum), preservative (sodium benzoate), and volume of carbon dioxide. These factors were varied at five levels each, resulting in a total of 36 experimental runs as seen in Table 1. The sensory responses observed was fitted to a second order polynomial regression model which includes the linear, 2 Factor Interactions (2FI) and Quadratic coefficients to predict the optimal conditions.

Table 1. Optimization of *soykunun-zaki* production process/design

Variables	4 factorial levels				
	-2	-1	0	1	2
Volume of water(ml)	150L	200L	250L	300L	350L
Stabilizer (Xanthan gum) (g)	1.0%	1.5%	2.0%	2.5%	
Preservative (sodium benzoate) (g)	0.05%	0.1%	0.15%	0.2%	0.25%
Volume of CO_2 (g) 1.0g/L	1.5g/L	2.0g/L	2.5g/L	3.0g/L	

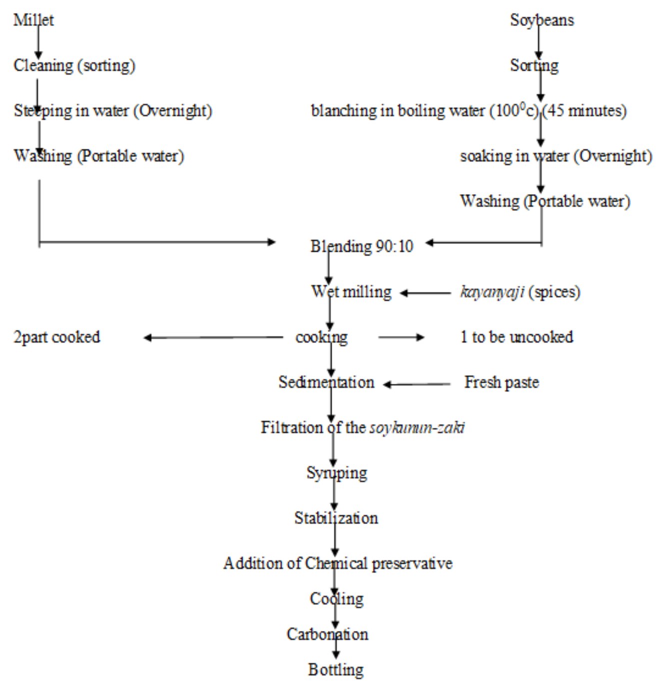

Figure 1. Flow chart for the production of stabilized and carbonized Soykunu-zaki

Sensory Evaluation

A panel of semi trained sensory evaluators were selected to assess the sensory attributes of the carbonated *Soykunun-zaki*. Panelists evaluated the beverage based on a 9-point hedonic scale for attributes such as taste, aroma, color, mouthfeel, consistency and overall acceptability. Their preference was rated on a hedonic scale of nine (9) points. Where 9 denotes extremely liked, 8 denotes liked very much, 7 denotes liked moderately, 6 denotes liked much, 5 denotes neither like nor dislike, 4 denotes dislike, 3 denotes dislike moderately, 2 denotes dislike very much, and 1 denotes disliked extremely. The samples were served in transparent disposable cups at the same time. Bottled water was provided for mouth rinsing between sample tastings [12].

Statistical Analysis

Design expert (version 13), a statistical software package was used in the statistical analysis. The sensory scores from the panelists were used as responses in the response surface analysis. Multiple regression models were fitted to the data to analyze the effects of the independent variables and their interactions on the sensory attributes. The models were evaluated based on their goodness of fit and predictive power.

3. Results and Discussion

Sensory profile of carbonated soykunun-zaki samples

The result of the sensory characteristics of the optimized carbonated soykunun-zaki samples are presented in Table 2.

Numerical optimization of production process parameters for sensory evaluation of soykununzaki samples

The optimal conditions for carbonated *Soykunun-zaki* production were identified based on maximizing overall acceptability while balancing other sensory attributes. A moderate volume of beverage, the use of xanthan gum as a stabilizer, sodium benzoate as a preservative, and an optimal level of carbon dioxide were found to yield the most favorable sensory profile as predicted by Design expert software (Table 3).

Table 2. Sensory Characteristics of Soykunun Zaki Samples

Run	A	B	C	D	Taste	Colour	Mouth feel	Consistency	Aroma	Overall Acceptance
1	200	2	0.2	2.5	6.67	5.94	6.40	6.34	5.89	6.25
2	250	1.5	0.15	2	6.34	6.14	7.00	6.40	6.14	6.43
3	350	1.5	0.15	2	6.87	6.57	6.40	6.00	7.30	6.81
4	300	1	0.2	2.5	6.57	5.83	7.50	6.54	7.00	6.62
5	200	1	0.1	1.5	6.54	6.40	6.30	7.14	7.54	6.65
6	200	1	0.2	2.5	6.38	6.21	7.00	7.43	7.20	6.74
7	250	2.5	0.15	2	6.40	6.71	6.40	6.89	6.66	6.56
8	300	2	0.2	1.5	6.00	6.57	7.00	6.54	5.89	6.47
9	250	1.5	0.15	2	6.51	6.60	6.86	6.71	6.57	6.70
10	300	2	0.1	2.5	6.46	6.14	6.70	6.57	6.71	6.55
11	250	1.5	0.15	2	6.57	6.40	6.57	6.20	6.43	6.46
12	250	1.5	0.15	2	6.60	6.70	6.49	6.86	6.86	6.69
13	250	1.5	0.15	2	6.00	6.30	6.86	6.29	7.66	6.58
14	300	2	0.2	2.5	6.29	5.77	6.30	5.71	5.91	6.02
15	250	1.5	0.25	2	6.40	6.38	6.80	6.54	6.00	6.22
16	250	1.5	0.15	1	6.00	6.00	6.57	7.43	6.30	6.38
17	250	0.5	0.15	2	6.57	6.14	6.90	6.40	6.89	6.48
18	250	1.5	0.15	2	6.10	6.57	6.23	5.83	6.51	6.32
19	300	1	0.1	2.5	6.86	6.57	6.72	7.20	7.00	6.77
20	250	1.5	0.15	2	6.30	6.60	6.40	5.96	7.30	6.56
21	300	2	0.1	1.5	6.00	6.40	6.20	6.60	6.30	6.37
22	200	2	0.1	2.5	7.00	6.86	6.23	6.50	6.86	6.63
23	200	1	0.2	1.5	6.00	6.40	6.71	7.30	6.86	6.60
24	200	1	0.1	2.5	6.71	6.86	6.50	7.00	6.57	6.76
25	250	1.5	0.15	2	6.86	6.34	6.00	6.29	6.43	6.39
26	300	1	0.1	1.5	6.57	6.80	6.57	6.69	6.70	6.63
27	250	1.5	0.15	2	6.68	6.71	6.00	6.71	6.71	6.62
28	150	1.5	0.15	2	6.09	6.60	6.50	7.00	6.09	6.41
29	250	1.5	0.15	3	6.70	6.71	6.90	6.70	6.60	6.77
30	250	1.5	0.05	2	6.83	6.71	7.00	6.50	6.57	6.74
31	200	2	0.1	1.5	6.64	6.60	6.70	6.31	6.71	6.61
32	250	1.5	0.15	2	6.61	6.74	6.57	7.00	6.86	6.73
33	250	1.5	0.15	2	6.23	6.86	6.57	6.80	7.40	6.59
34	200	2	0.2	1.5	6.86	6.50	6.40	6.29	7.00	6.48
35	300	1	0.2	1.5	6.40	6.90	6.90	8.00	7.14	6.97
36	250	1.5	0.15	2	6.00	6.29	6.86	6.80	6.90	6.50

KEY: A = Volume of Sample; B = Stabilizer; C = preservative; D = Volume of CO_2

Table 3. Optimization and prediction ofsensory characteristics ofcarbonated soykunun-zakiby Design Expert

	B	C	D	Taste	Colour	Mouth feel	Consistency	Aroma	Overall Acceptanc
[illegible]	1.639	0.100	2.500	6.679	6.542	6.590	6.377	6.755	6.639

KEY: A = Volume of Sample; B = Stabilizer; C = preservative; D = Volume of CO_2

Taste

The scores for taste ranged between 6.00 and 7.00 (Table 2). The lowest score was recorded (6.00) for samples 13,16, 21, 23 and 36 while the highest score was recorded for 22. The range of scores for samples with the highest panel score (22) showed it was liked moderately by the panelists. The 2FI model was selected for the optimization process parameter for taste. The equation in terms of actual factors is given in equation 1.

TASTE = + 4.2979 +0.0081A +1.6051B -5.1291C +0.2441D -0.0079AB +0.008AC +0.0011AD +2.6227BC -0.0217BD -1.5577CD………………………….…………………. (1)

Where: A = Volume of Sample; B = Stabilizer; C = preservative; D = Volume of CO_2

Results of ANOVA fortaste isshownin Table 4. The Model F-value of 2.66 implied that the model was significant. There is only a 2.30% chance that an F-value this large could occur due to noise. P-values less than 0.0500 indicated that the model terms were significant. In this case C, D, AB were the significant model terms.

The R^2, adjusted R^2 and Predicted R^2 were calculated to be 0.4764, 0.2670 and -0.0377 with an adequate precision of 7.2133. This shows an adequate signal that indicates the model can be used to navigate the design space. However, a negative Predicted R^2 implies that the overall mean may be a better predictor of the response than the current model.

The Lack of Fit F-value of 0.50 implies the Lack of Fit is not significant relative to the pure error. There is 89.11% chance that a Lack of Fit F-value this large could occur due to noise. Hence, the model could be used for prediction.

Table 4. ANOVA for Taste

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1.51	10	0.1511	2.66	0.0230	Significant
A-Vol. of Sample	0.0336	1	0.0336	0.5918	0.4489	
B-Stabilizer	0.0087	1	0.0087	0.1525	0.6995	
C-Preservative	0.2565	1	0.2565	4.51	0.0437	
D-vol. of CO2	0.4612	1	0.4612	8.12	0.0086	
AB	0.6356	1	0.6356	11.19	0.0026	
AC	0.0081	1	0.0081	0.1417	0.7098	
AD	0.0143	1	0.0143	0.2523	0.6198	
BC	0.0688	1	0.0688	1.21	0.2817	
BD	0.0005	1	0.0005	0.0083	0.9281	
CD	0.0243	1	0.0243	0.4271	0.5194	
Residual	1.42	25	0.0568			
Lack of Fit	0.5499	14	0.0393	0.4965	0.8911	not significant
Pure Error	0.8703	11	0.0791			
Cor Total	2.93	35				

The effect of the production process of the response surface plots on the taste is shown in figure 2. The interaction between the volume of sample and stabilizer concentration is depicted. A combination of high volume of sample (300ml) and a low level of stabilizer concentration (1,03g/ml) led to nearly 70% level acceptability of the beverage (6.65) with other variables remaining constant at preservative concentration of 0.15% and Volume of CO2 at 2g/L. This is in agreement with earlier findings of [13,14].

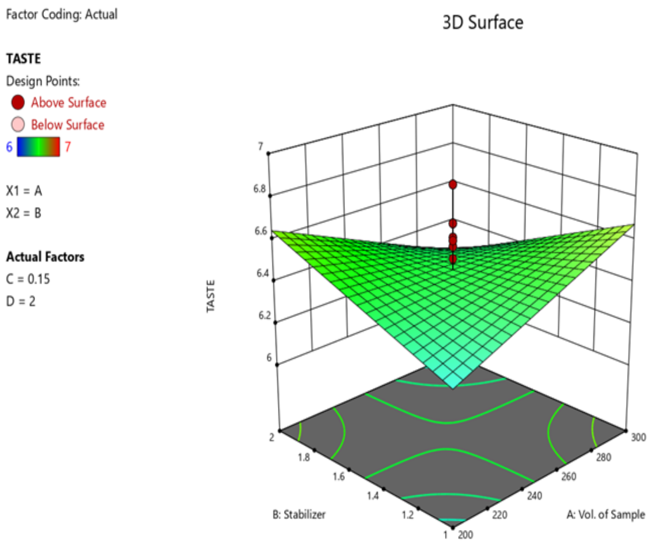

Figure 2. 3D contour plots generated by Design Expert (Stat Ease,Inc.) of the significantly interacting model terms(a) A: Volume ofSample and B: Stabilizer; The dots indicate the axial and centre design points

Color

The scores for color ranged between 5.77 and 6.90 as seen in Table 2. The highest score here was recorded for sample 35 produced with volume of sample 300ml, stabilizer concentration of 1g, preservative concentration 0.2g and volume of CO_2 at 1.5g/L while the lowest score (5.77) recorded for sample 14was produced at volume of sample 300ml, stabilizerconcentration of 2g,preservative concentration 0.2g and volume of CO_2 at 2.5g/L which showed that the samples were neither liked nor disliked by the panelists as seen in Table 2. A two-factor interaction (2FI) model was chosen, and the result is shown in Table 5. The equation in terms of actual factors is given in equation 2.

Colour = +1.5603 +0.0125A +0.9099B +6.1996C +2.5616D -0.0031AB +0.020AC -0.0058AD +0.1890BC -0.0810BD -7.1176CD …………………………………………… (2). Where: A = Volume of Sample; B = Stabilizer; C = preservative; D = Volume of CO_2

The Model F-value of 2.25 implies the model is significant. There is only a 4.85% chance that an F-value this large could occur due to noise. P-values less than 0.0500 indicate model terms are significant. In this case C, AD, CD are significant model terms. Values greater than 0.1000 indicate the model terms are not significant.

The Lack of Fit F-value of 1.59 implies the Lack of Fit is not significant relative to the pure error. There is a 22.33% chance that a Lack of Fit F-value this large could occur due to noise. Non-significant lack of fit shows the model is good for prediction. With a sufficient precision of 7.9634, the R^2, adjusted R^2, and predicted R^2were computed to be 0.4740, 0.2636, and -0.2388 respectively, indicating a sufficient signal where a ratio larger than 4 is preferred. This suggests that navigating the design space is possible using the model.

The response surface plot for the 2FI of colour is seen in figure 3(a) and (b). This presents an interaction between Volume of sample and volume of CO_2 in figure 3(a). It showed that with increase in the volume of sample and volume of CO_2 within the range of 1.5 – 1.7g/L, there was a corresponding increase in the acceptance of the likeness by the panelists [15]. As reported by [15], this might be due to the binding effect of CO_2in water absorption thus preventing color loss in beverages. The trend observed in the interaction between preservative concentration and volume of CO_2in figure 3(b) showed that the panelists liked the samples with increases in the volume of CO_2 and low concentrations of preservatives. The possibility of this can be attributed to the preservative role of CO_2in beverages as earlier reported by [16].

To The results of ANOVA for mouthfeel are presented in Table 6. Linear model was selected for the sensory parameter. The final regression model in terms of actual values in given in equation 3 as:

Mouth feel = +6.2784 +0.0012A -0.272B +1.5803C +0.1017D………………………. (3)

The Model F-value of 2.04 implies the model is not significant relative to the noise. There is 11.26% chance that an F-value this large could occur due to noise. P-values less than 0.0500 indicate model terms are significant. In this case B is a significant model term. Values greater than 0.1000 indicate the model terms are not significant. The Lack of Fit F-value of 0.73 implies the Lack of Fit is not significant relative to the pure error. There is a 74.36% chance that a Lack of Fit F-value this large could occur due to noise which makes the model suitable for prediction.

A negative Predicted R^2 of -0.0449 implies that the overall mean may be a better predictor of the response than the current model. In some cases, a higher order model may also predict better. However, the Adequate Precision ratio of 5.802 is greater than 4 which is desirable as it indicates an adequate signal. This model can be used to navigate the design space.

The interaction between volume of sample and stabilizer concentration is shown in figure 4. The response surface plot for this interaction showed significant effects of the interaction on the mouthfeel of the beverage. This influence could be attributable to the presence of added xanthan gum, which acts as a hydrophilic biopolymer with a polysaccharide or protein structure. Stoke's law states that stability is produced by increasing the viscosity of the continuous phase and slowing the movement of dispersed phase droplets [17]. This is true of the beverage as the binding properties of the gum provided stopped dissolved particles from free floatation which is one of the reasons for the rejection of the traditional kunuzaki. Furthermore, as reported by [18], xanthan gum has been demonstrated to enhance the rheological and textural characteristics of drinks, resulting in improved mouthfeel, consistency, stability, and the avoidance of precipitation and two-phase development during storage.

Table 5. ANOVA for Color

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1.48	10	0.1475	2.25	0.0485	significant
A-Vol. of Sample	0.0293	1	0.0293	0.4474	0.5097	
B-Stabilizer	0.0001	1	0.0001	0.0010	0.9754	
C-Preservative	0.4171	1	0.4171	6.37	0.0183	
D-vol. of CO2	0.0386	1	0.0386	0.5890	0.4500	
AB	0.0972	1	0.0972	1.48	0.2344	
AC	0.0419	1	0.0419	0.6394	0.4315	
AD	0.3376	1	0.3376	5.16	0.0320	
BC	0.0004	1	0.0004	0.0055	0.9417	
BD	0.0066	1	0.0066	0.1003	0.7541	
CD	0.5066	1	0.5066	7.74	0.0101	
Residual	1.64	25	0.0655			
Lack of Fit	1.09	14	0.0782	1.59	0.2233	not significant
Pure Error	0.5420	11	0.0493			
Cor Total	3.11	35				
Std. Dev.	0.2559		**R^2**	0.4740		
Mean	6.47		**Adjusted R^2**	0.2636		
C.V. %	3.96		**Predicted R^2**	-0.2388		
			Adeq Precision	7.9634		

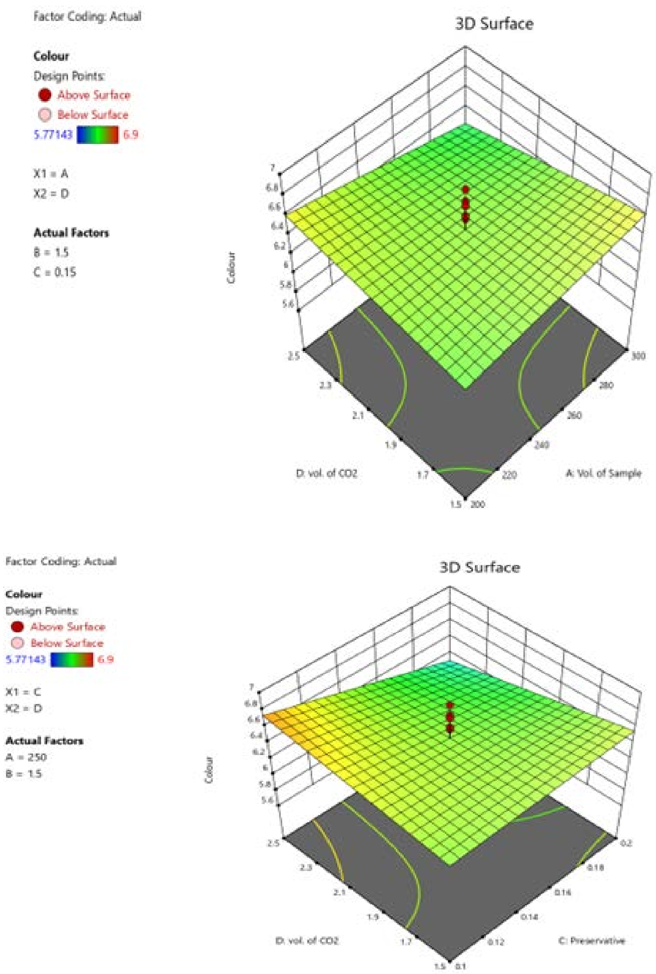

Figure 3. 3D contour plots generated by Design Expert (Stat Ease,Inc.) ofthe significantly interactingmodel terms(a) A: volume of sample and D: Volume of CO_2;(b) C: preservative; and D: Volume ofCO_2

Table 6. ANOVA for Mouthfeel

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	0.7459	4	0.1865	2.04	0.1126	not significant
A-Vol. of Sample	0.0872	1	0.0872	0.9551	0.3360	
B-Stabilizer	0.4467	1	0.4467	4.89	0.0344	
C-Preservative	0.1499	1	0.1499	1.64	0.2096	
D-vol. of CO2	0.0622	1	0.0622	0.6812	0.4155	
Residual	2.83	31	0.0913			
Lack of Fit	1.61	20	0.0805	0.7254	0.7436	not significant
Pure Error	1.22	11	0.1109			
Cor Total	3.58	35				
Std. Dev.	0.3021		**R²**	0.2086		
Mean	6.61		**Adjusted R²**	0.1065		
C.V. %	4.57		**Predicted R²**	-0.0449		
			Adeq Precision	5.8018		

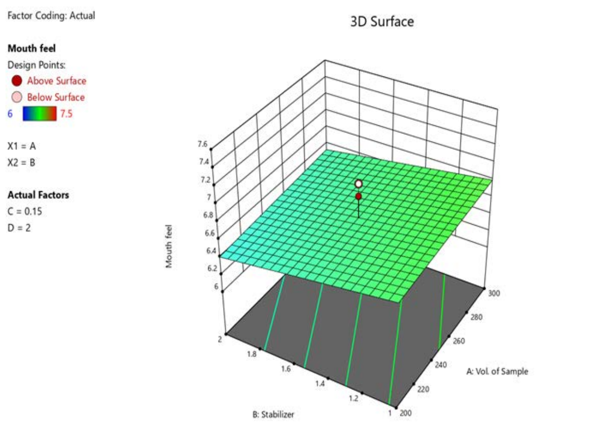

Figure 4. 3D contour plots generated by Design Expert (Stat Ease, Inc.) of the significantly interacting model termsof A: Volume of Sample and B: Stabilizer; The dots indicate the axial and centre design points.

Consistency

A linear model was selected for the consistency of the carbonated *Soykunun-zaki* beverage. The results in Table 6. Showed the general finding that the model was not significant. However, the uniformity was significantly impacted by the presence of added xanthan gum stabilizer. The thickening and stabilizing properties of xanthan gum, alsoincreased viscosity, inhibitedingredient separation as already stated, facilitating emulsification, and evenly suspended particles to improve mouthfeel and lessen syneresis [19]. Its benefits improvedthe sensory quality and experience of the consumer by helping to achieve desired mouth feel, preserving uniformity in a range of beverages; from salad dressings to smoothiesas has been reported [20].

The **Model F-value** of 2.38 implies there is a 7.34% chance that an F-value this large could occur due to noise. **P-values** less than 0.0500 indicated model termsthat are significant. In this case B is a significant model term. The **Lack of Fit F-value** of 1.58 was not significant relative to the pure error showing a 22.07% chance that a Lack of Fit F-value this large could occur due to noise. The negative **Predicted R²** implies that the overall mean may be a better predictor of the response than the current model. In some cases, a higher order model may also predict better. A ratio larger than 4 is preferred, and the Adequate Precision of 5.621 suggests a sufficient signal that may be utilized to navigate the design space. The final regression model in terms of actual values is given in equation 4 as:

Consistency = +8.32316 -0.0020A -0.4547B +0.1874C - 0.2526D………………..………… (4)

The response surface plot for the consistency of the beverage is shown in figure 4. It showed significant ($P<0.05$) interaction between volume of sample and stabilizer concentration. The plot revealed that sample consistency at every level was affected by the interaction of the volume of sample, and stabilizer concentration at ranges between 1-1.8%.

Aroma

The scores for aroma ranged from 5.68 to 7.65 as shown in Table 2. Sample 14 (250ml), stabilizer concentration (1.5%), preservative concentration (0.15%) and volume of CO_2 (2g/L) had the highest score while sample 8 with volume of sample 300ml, stabilizer concentration at 2%, preservative concentration of 0.2% and volume of CO_2 at 1.5g/L had the lowest score. These scores indicated that sample aroma perception decreased with increasing volumes of the beverage and CO_2 concentration. The Linear model equation for the optimization process parameter for aroma in terms of actual factors is given in equation 5.

Aroma = +7.6605 +0.0003A -0.4333B -2.2133C - 0.0333D………………………………. (5)

The results Table 7. shows the ANOVA for the Aroma scores. The **Model F-value** of 1.86 implied that the model was not significant relative to the noise. There was a 14.19% chance that an F-value this large could occur due to noise**. P-values** less than 0.0500 indicated model terms there were significant. In this case B (stabilizer concentration) was a significant model term. The **Lack of Fit F-value** of 0.94 showed that the Lack of Fit was not significantrelative to the pure error. There is a 56.73% chance that a Lack of Fit F-value this large could occur due to noise.

Table 7. ANOVA for Consistency

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1.88	4	0.4694	2.38	0.0734	not significant
A-Vol. of Sample	0.2516	1	0.2516	1.27	0.2677	
B-Stabilizer	1.24	1	1.24	6.28	0.0176	
C-Preservative	0.0021	1	0.0021	0.0107	0.9184	
D-vol. of CO2	0.3830	1	0.3830	1.94	0.1736	
Residual	6.12	31	0.1975			
Lack of Fit	4.54	20	0.2269	1.58	0.2207	not significant
Pure Error	1.58	11	0.1440			
Cor Total	8.00	35				
Std. Dev.	0.4444		**R²**	0.2347		
Mean	6.65		**Adjusted R²**	0.1360		
C.V. %	6.68		**Predicted R²**	-0.0641		
			Adeq Precision	5.6214		

As shown in Table 8. the Adequate Precision of 5.299 indicated an adequate signal because a ratio greater than 4 is desirable and it measured comparatively the signal to noise ratio. This model can be used to navigate the design space. However, the R^2, adjusted R^2 and Predicted R^2were calculated to be 0.1939, 0.0898 and -0.0894. A negative Predicted R² implies that the overall mean may be a better predictor of your response than the current model. In some cases, a higher order model may also predict better.

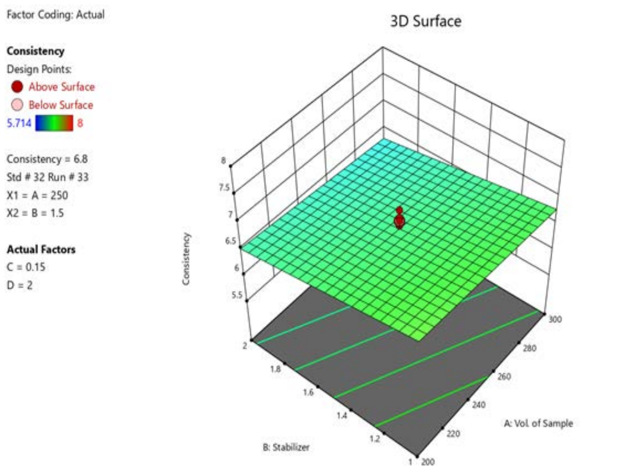

Figure 5. 3D contour plots generated by Design Expert (Stat Ease, Inc.) of the significantly interacting model termsof A: Volume of Sample and B: Stabilizer; The dots indicate the axial and centre design points

Table 8. ANOVA for Aroma

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	1.44	4	0.3590	1.86	0.1419 not significant
A-Vol. of Sample	0.0087	1	0.0087	0.0453	0.8328
B-Stabilizer	1.13	1	1.13	5.85	0.0217
C-Preservative	0.2939	1	0.2939	1.53	0.2260
D-vol. of CO2	0.0067	1	0.0067	0.0347	0.8534
Residual	5.97	31	0.1927		
Lack of Fit	3.77	20	0.1883	0.9387	0.5673 not significant
Pure Error	2.21	11	0.2006		
Cor Total	7.41	35			
Std. Dev.	0.4389		**R^2**	0.1939	
Mean	6.71		**Adjusted R^2**	0.0898	
C.V. %	6.54		**Predicted R^2**	-0.0894	
			Adeq Precision	5.2985	

The response surface plot for the aroma of the beverage is shown in figure 6. The interactions showed that increases in the volume of sample and stabilizer concentration led to lowered values in the perception of the beverage aroma. A corresponding increase is observed in the likeness of the samples as volume of sample increased with stabilizer concentrations from the range of 1- 1.8%. A similar result has been reported by [21]. Variations in sample volume and stabilizer concentration cannot only impact the dispersion and retention of aroma compounds, altering the sensory experience for consumers but it is also expected that increasing levels of the stabilizer will lead to masking of the aroma of the beverage since the stabilizer is a bland product. Proteins, on the other hand, are recognized to have the ability to hold onto flavor, while carbohydrates barely hold onto flavor in drinks. Here, the soymilk was added to boost the beverage's protein level hence increasing its improved aroma rating. To inactivate the lipoxygenase enzyme in soymilk and enhance the flavor, thermal procedures including pasteurization and blanching were applied [22,23]. This way only the natural kunun-zaki aroma might have perceptible levels and retained in the beverage.

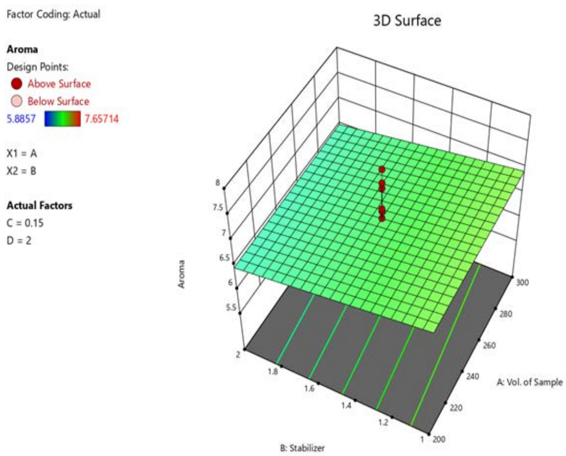

Figure 6. 3D contour plots generated by Design Expert (Stat Ease,Inc.)of the significantly interacting model termsof A: Volume of Sample and B: Stabilizer; The dots indicate the axial and centre design points

Overall Acceptance

The linear model selected for the overall acceptance of the carbonated *Soykunun-zaki* beverage is shown in Table 8. The Model F-value of 3.29 indicated that the model was significant. There was only a 2.32% chance that an F-value this large could occur due to noise. P-values less than 0.0500 indicated model terms that were significant. In this case B (stabilizer concentration), C (CO_2 volume) were significant model terms. The Lack of Fit F-value of 1.92 showed that the Lack of Fit was not significant relative to the pure error. There is a 13.39% chance that a Lack of Fit F-value this large could occur due to noise. Non-significant lack of fit is suitable for prediction. The negative **Predicted R^2** (-0.0058) implies that the overall mean may be a better predictor for the response than the current model. In some cases, a higher order model may also predict better. The **Adequate Precision** of 6.170 measured the signal to noise ratio. A ratio greater than 4 in this case is desirable as it indicates an adequate signal. This model can be used to navigate the design space.

The plot of significant model parameters (figure 7) showed the response surface plot for the overall acceptance of the beverage. The plot showed that samples with larger sample volumes and lower stabilizer concentrations scored higherwhich is consistent with the earlier observations. The values obtained here were found within the range of 6.02 -6.93 which according to the hedonic scale were liked by the panelists giving nearly 70% acceptance. Consumers were observed to like all the beverage samples which is positive for their commercialization. In order for a new product to be successful in the market, people must embrace it, as these current results indicate for the carbonated *Soykunun-zaki* beverage. The anova for the overall acceptability is shown in Table 9.

Table 9. ANOVA for Overall Acceptance

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	0.3554	4	0.0888	3.29	0.0232	significant
A-Vol. of Sample	0.0005	1	0.0005	0.0203	0.8876	
B-Stabilizer	0.2041	1	0.2041	7.57	0.0098	
C-Preservative	0.1462	1	0.1462	5.42	0.0266	
D-vol. of CO2	0.0046	1	0.0046	0.1694	0.6834	
Residual	0.8363	31	0.0270			
Lack of Fit	0.6498	20	0.0325	1.92	0.1339	not significant
Pure Error	0.1865	11	0.0170			
Cor Total	1.19	35				

Std. Dev.	0.1643	**R^2**	0.2982
Mean	6.55	**Adjusted R^2**	0.2077
C.V. %	2.51	**Predicted R^2**	-0.0058
		Adeq Precision	6.1699

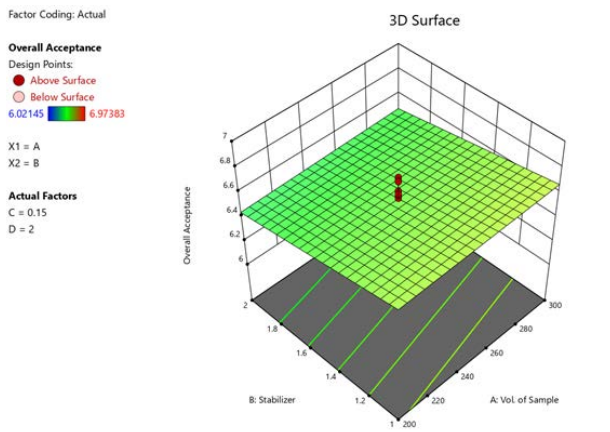

Figure 7. 3D contour plots generated by Design Expert (Stat Ease,Inc.)of the significantly interacting model termsof A: Volume of Sample and B: Stabilizer; The dots indicate the axial and centre design points

4. Conclusion

The findings from this study showed that the stabilizer and preservative concentration were significant<0.05. These findings provide valuable insights for producers of carbonated *Soykunun-zaki* in optimizing the production process to enhance the sensory appeal of the beverage. By understanding the impact of volume, stabilizers, preservatives, and carbon dioxide levels, producers can tailor their methods to meet consumer preferences. Response surface analysis proved to be an effective tool in optimizing the sensory evaluation of carbonated *Soykunun-zaki*. The study identified optimal conditions based on desirability concept indicated that 287.242ml for volume of sample, 1.639% for stabilizer concentration, 0.100% for preservative concentration and 2.500g/L of $C0_2$ for balancing various factors will produce a beverage with enhanced sensory attributes and overall consumer satisfaction. Future research could explore the impact of packaging and storage conditions on the sensory properties of carbonated *Soykunun-zaki*.

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Conflict of Interest

The authors declare no conflict of interest.

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