Development of method of optimized flavor production systems design based on nano-emulsification Kawista (*Feronia limonia*) Fruit extraction

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Abstract. 'Kawista' (*Feronia limonia*) as a tropical fruit has unique flavor that can be applied as a flavor for food products. Flavor as volatile components are unstable by environment factors such as temperature and storage. Flavor nano emulsification form to improve the stability towards environment and increase its use in food products. Research carried out is system development of the nano emulsification Kawista extract flavor with sonication method. The best treatments are selected by Response Surface Methodology (RSM) for independent variable are amplitude (70-100%), time (90-150s) and temperature (5-45^{o}C) controlled by the software of the device. The Flavor Extraction by maceration technique extended highest yield and flavor components. Nano-emulsions made with composition 1% (w/w) flavor extract, 2% (w/w) surfactant (tween 80), 0.25% Gum, and 96.75% (w/w) deionized water. The probe of sonication successfully for preparing stable O/W nano emulsions at amplitude, time and temperature 81.01%, 150s, 45^{o}C, respectively. Characteristic of nano-emulsions i.e energy input (15.489J), viscosity (2.076 mPa.s), droplet size (13.446nm), and Polydispersity index (0.469).

***Keywords**: Feronia limonia, flavor, sonication, nano emulsions, droplet size*

1. Introduction

The use of natural food to increase due to awareness of the community to consume safe and nutritious food and have a positive impact on health. New material food excavations including enhancement of existing ingredients have been pursued by improving the cultivation, handling of post harvest, processing, distribution and storage, until of serving to obtain optimal food benefits. The utilization of 'Kawista' fruit (wood apple) especially aroma component that is the provision in the form of food flavor will provide a positive contribution in the needs of natural food through agricultural processing technology.

Kawista (*Feronia limonia*) is a plant that includes the citrus family (*Rutaceae*). As a tropical Asian plant, it spread unevenly and generally grows wildly of the forest and sandy soil like on the beach, and its decreases of population (rare plant). Kawista can be found in Aceh, Rembang, Madura and Bima. It diameter around 10cm, hard peel, and grayish white. As a food, young Kawista can be make for 'Rujak' and ripe fruit to syrup product because the distinctive aroma is very preferred [1].

The perfectly ripe Kawista fruit has a distinctive aroma and can provide a flavor to the food. Flavor component analysis to use Gas Cromatography-Olfactometry (GC-O) and Aroma Extract Dilution Analysis (AEDA) technique, successfully identified and described some character impact odorants that give the feel of aroma to flavor characteristics of Kawista. The dominant aromas of these components include: fruity, sweet, banana like, melon-like, cheese (butter-like), herbaceous (green) and sour. The volatile component of the Kawista flavor that can be identified by GC-MS includes 75 volatile components consisting of 28 ester (37.3%), 11 alcohol (14.7%), 10 aldehyde (13.3%), 1 acetyl (1.3%), 10 ketones (13.3%), 4 lactone (5.3%), 1 heterocyclic aromatic (1.3%), 4 hydrocarbon (5.3%), 1 furan (1.3%) and 5 carboxylic acid (6.7%) [2].

Flavor component extraction aims to obtain flavor components and remove other components. It can be vacuum distillation method, extraction with solvent (maceration), Likens-Nickerson extraction and headspace. The method of extraction with maceration technique to use organic solvent (1:1) got the best of Kawista extract flavor similar to the original fruit [2].

Flavor components of fruits extract as volatile compounds is volatile unstable under normal environmental conditions and during processing. To maintain the stability of food flavors can be done by binding the flavor components in the form of emulsions. Stability of folic acid it can be increased by making triple emulsion, it water-in-oil-in-water (W/O/W) emulsion using Maltodextrin-Whey Protein binder in nano emulsion [3].

Nano technology can be applied in food processing technology in the form of nano emulsion. The definition of nanotechnology in food processing is the manufacture of nano-sized food materials of 20-200 nm. The characteristic of the nano emulsion product are transparent, translucent and uncreaming. Nano emulsion is resistant to creaming because it has sufficient Brownian motion to overcome the separation of gravity forces. It is also resistant to flocculation because of its highly efficient steric stability. Most nano emulsion are stable by synthetic surfactants that tend to have long hydrophilic groups [4].

Technique to make nano emulsions there are two ways i.e. high energy and low energy approach. It is high energy methods to use mechanical equipment such as high pressure homogenizer, micro fluidizer, and sonication methods. The formation of a low energy nano emulsion is produced as a result of a phase transition during an emulsification process in which there is a change in composition with a constant temperature. Frequently used methods are membrane emulsification, spontaneous emulsification, emulsion inversion point, phase inversion point, solvent displacement [5].

Ultrasonic is a cyclical sound pressure with a frequency greater than the upper limit of human hearing in the frequency range 20 kHz-10 MHz. The ultrasonic chemical effect in the liquid comes from several nonlinear acoustic phenomena, where cavitation is the most important. Acoustic cavitation is the formation, growth and breakup of bubbles in a liquid that is irradiated with sound or ultrasonic [6].The intensity of the propagating ultrasonic waves will bring energy to a surface area per unit of time. If the ultrasonic wave energy passes through the tissue, it releases heat energy so that there is a warming which results in increased tissue temperature and then causing the effects of cavitation, namely the formation, growth and bubble burst in a liquid. The rupture of the cavitation bubble can produce a temperature of about 5000 ^{o}C and a pressure of 2000 atm [7].

The objective of the research is to develop a nano emulsion Kawista with ultra-sonication (high energy method). The nano emulsion form of Oil in Water (O/W) to provide flavor of Kawista extract in liquid form. The sonicator probe settings include the intensity of amplitude, time and temperature as independent variables. The research parameters of energy consumption, viscosity, particle size, and polydispersity index (PDI) as dependent variables. The best model form to use Response Surface Methodology (RSM) method, so obtained the mathematical model and its significance level.

Optimization Techniques with RSM

Optimization of nano emulsion process can be done by using one of the process optimization techniques with RSM. It is a statistical study where this technique can be used to analyze and to make the model with one or more treatments in the study [8, 9, 10]. The response of a process as dependent variable can be predicted after to insert the lower limit and upper limit of a value as an independent variables. The formula of the free variables selected through the RSM technique can be used to develop, improve, and optimize the process. The mathematical model of RSM technique can explain chemical or biochemical processes so as to illustrate the best response of a process. Another advantage of RSM method is that it does not require large amount of treatments, so it is efficient in terms of cost and time of research.

Optimization techniques using approaches from statistics and engineering mathematics are facilitated by the Design Expert Program (DX) RSM Box-Behnken Design. The stages in optimization techniques using RSM are 1) creation of formulation and response design, 2) formulation, 3) response analysis, 4) optimization. Verification of results is required to prove the predicted value of the suggested response value.

The design of the formulation and response is done by determining the research variables. At this stage it should establish the lower and upper limits of the variable that provides a response based on the literature review or trial and error with preliminary research. The minimum and maximum limit values entered into the DX 7® RSM Box-Behnken Design program are further processed by the program that will produce the treatment formulas to be analyzed and the measured response.

The formulation stage is the actual stage of the study according to the process conditions i.e. the formula obtained from the DX software. Response analysis phase is to analyze the influence between variables with Analysis of Varian (Anova) then selected the highest significance value of the model obtained whether Linear, Quadratic, Special Cubic, or Cubic. Models that provide significance and non-significance in the lack of fit were selected to analyze the variables. Normality tests are marked by the distribution of data the closer to the normal line, indicating the actual results will be close to the results predicted by the program.

In the optimization stage, the DX program will perform optimization of data and response measurement data with the output in the form of recommendations of some optimum formula according to the program. The best formula is maximum desirability value. The value of desirability is the value of the optimization that indicates the ability of the program to meet the desires based on the criteria set on the final product [10]. The results obtained from the best conditions continued to the stage of verification, which is done processing and analysis of the results in accordance with the best formulation of RSM so that it can be seen suitability in the verification stage.

2. Research Methods

2.1 Preparation of Kawista Flavor Extract Nano emulsion

The necessary ingredients are flavor Kawista extract, Tween 80 (Merck, Germany), Sodium azide as an antimicrobial agent (Sigma Chemicals Company St. Louis, USA) and Deionized water. Procedures for the manufacture of nano emulsion flavor Kawista with ultrasonic adopted from Hashtjin, AM, and Abbasi, S. [11] on the manufacture of nano emulsion from orange peel essential oil which component of flavor extract (1% w/w) as oil phase, added emulsifier Tween 80 (2% w/w), and 0.25% w/w the solvent fraction comprises a mixture of Persian Gum (PG) and Gum Tragacanth (GT) (75:25) and deionized water (96.75% w/w) as an aqueous phase. The first stage of the mixture is placed in a beaker glass homogenized with a magnetic stirrer (700 rpm for 15 minutes) at room temperature. After that, it sonication to the solution (Sonicator 4000, 20 kHz, cylinder sonotrode diameter 19.1 mm, Misonix, Inc, New York) refer to running output the RSM method on amplitude (70-100%), time (90-150 s) and temperature (5-45 ^{o}C) (see at the Table 1 and Table 2).

2.2 Nano emulsion measurements

*2.2.1. Droplet size and Polydispersity Index (PDI).*The droplet size of nano emulsion is determined by photon correlation spectroscopy. Sample (0.1 ml) of nano emulsion was dispersed in 50 ml of water.

Measurements were made using Zetasizer 1000 HS (Zetasizer Nano Zs, Malvern Instrument, Malvern, UK). The scattering light is monitored at 25°C at an angle of 90°. The analysis of the dispersion and the size of the granular nanoparticles were performed by Particulate System-Particle Size Analyzer which can measure the size distribution with the range 2 nm to 7000 nm.

2.2.2. Rheological measurements. Viscosity was measured by Brookfield viscometer (LVDV Pro II, Brookfield Engineering Laboratories, USA) with a spindle S34. The viscosity of the formulation (0.5 g) was determined without dilution using Brookfield DV III ultra-V6.0 RV cone and rheometer plate at 25 ± 0.5°C.

2.3 Research design and Data analysis
Development of Kawista flavor nano emulsion production with ultra-sonication to test the influence of independent variable that is amplitude 70-100% (X_1), time variation 90-150s (X_2) and temperature 5-45°C (X_3) to dependent variable i.e. energy input (Y_1), viscosity (Y_2), droplet size (Y_3) and PDI (Y_4). The experimental design to use 2^3 factorial with central composite design method (Table 2). Data analysis includes descriptive analysis such as tabulation of data, presentation of images, and graphs, as well as statistical data analysis to examine the effect of treatment and choose the best formula. Test RSM optimization technique with RSM using Design Expert Software 7.0 tool.

3. Result and Discussion

3.1 System Development of Kawista Flavor Extract Nano emulsion with RSM
The procedure to make nano emulsion Kawista flavor adopted from Hashtjin, A.M., and Abbasi, S. [11] on the manufacture of nano emulsion orange peel essential oil. Optimization formula of nano emulsions by RSM technique. Nano emulsion formulation with ultra-sonication technique is to set minimum and maximum limit of operating system as independent variable i.e. amplitude value (70-100%), time duration (90-150s) and temperature of sonicator (5-45°C) (Table 1).

Table 1. RSM design of independent variables

Symbols	Independent variable	Min	Max	-alpha	+alpha
X_1	Amplitude (%)	70	100	59.7731	110.2269
X_2	Time (s)	90	150	69.5462	170.4538
X_3	Temperature (°C)	5	45	-8.6359	58.6359

Model of linear regression equation influence between research variables:

$$Y_i = a + a_1X_1 + a_2X_2 + a_3X_3 \quad (1)$$

Where the dependent variable Y_i, a constants, X_1 amplitude, X_2 time and X_3 temperature. Development of production system of nano emulsion Kawista flavor with ultrasonic technique refers to production of nano emulsion orange peel essential [9] obtain dependent variable data that is energy input 7.079-18.889J, viscosity 1.842-2.262 mPa.s, droplet diameter 14.123-33.103 nm, the polydispersity index ranges from 0.43-0.67. Overall result with RSM optimization technique obtained 20 run data presented in Table 2.

Table 2. Influence of different ultra-sonication conditions i.e. amplitude (X_1), time (X_2), and temperature (X_3) to energy input (Y_1), viscosity (Y_2), droplet size (Y_3) and PDI (Y_4) Kawista flavor nano emulsion

Run	Independent variable			Response			
	X_1	X_2	X_3	Y_1	Y_2	Y_3	Y_4
1	85.00	69.55	25.00	7.636	2.314	29.789	0.63
2	100.00	90.00	45.00	12.529	2.202	19.193	0.51
3	70.00	90.00	45.00	7.159	2.382	27.143	0.63
4	100.00	150.00	5.00	18.809	1.842	14.473	0.43
5	100.00	90.00	5.00	12.449	2.082	25.153	0.55
6	110.23	120.00	25.00	17.499	1.961	14.123	0.43
7	70.00	90.00	5.00	7.079	2.262	33.103	0.67
8	70.00	150.00	45.00	13.519	2.142	16.463	0.51
9	85.00	120.00	25.00	12.984	2.112	20.808	0.53
10	59.77	120.00	25.00	8.468	2.263	27.493	0.63
11	85.00	170.45	25.00	18.332	1.910	11.827	0.43
12	100.00	150.00	45.00	18.889	1.962	8.513	0.39
13	85.00	120.00	25.00	12.984	2.112	20.808	0.53
14	85.00	120.00	-8.63	12.917	2.011	25.820	0.56
15	85.00	120.00	25.00	12.984	2.112	20.808	0.53
16	85.00	120.00	25.00	12.984	2.112	20.808	0.53
17	85.00	120.00	25.00	12.984	2.112	20.808	0.53
18	85.00	120.00	58.63	13.051	2.213	15.796	0.50
19	70.00	150.00	5.00	13.439	2.022	22.423	0.55
20	85.00	120.00	25.00	12.984	2.112	20.808	0.53

This sonication process converts electrical signals into physical vibrations with ultrasonic waves with a frequency range 20 kHz-10 MHz. This vibration has a very strong effect on the solution, causing the outbreak of the molecule and the breaking of the cell. The sonication probe sends vibration to the sonication solution causing an effect of cavitation, the process of bubbles bursting in the fluid resulting from a sudden drop in pressure at a constant temperature. The cavitation bubble makes the particles have a diameter in the nano scale.

3.2 Energy Input

The energy input of nano emulsion production are 7.079-18.889J. The result of Anova test obtained p value <0.0001 which means independent variables (amplitude, temperature and operating time sonication) significant effect on dependent variable i.e. energy input. The linear regression equation effect of sonication operation condition to energy input is as follows:

$$Y_1 = 12.98 + 2.68X_1 + 3.18X_2 + 0.040X_3 \quad (2)$$

Based on the mathematical model can be illustrated that all the independent variables positively affect the energy (Y_1) is characterized by positive-positive constants. The largest value of constant is at time (seconds) of sonication operation equal to 3.18 times, amplitude (%) 2.68 times, and temperature (^oC) gives the least influence is 0.04 times. The amount of energy required to manufacture nano emulsion droplets to a minimum, the factors contributing to the increase in energy can be reduced. Three-dimensional image of RSM method calculation duration time and amplitude can be seen in Figure 1.

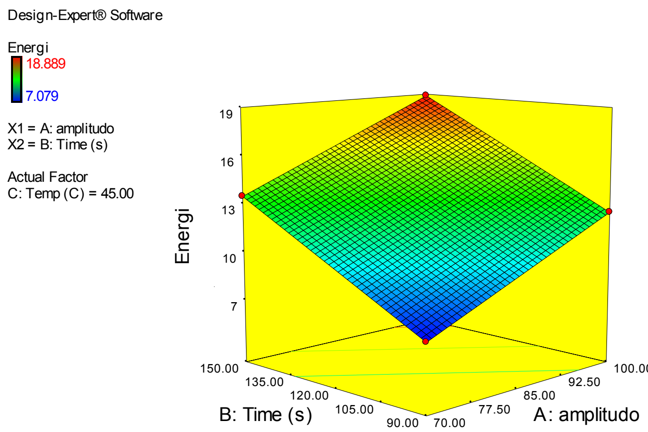

Figure 1. Response surface plot effect of time and amplitude of sonication on energy input

3.3 Rheology

The characteristic of rheology is expressed as the viscosity and flow of liquid food products measured using a viscometer. The widely used viscometer is rotational viscometer. The principle it by measuring the magnitude of the resistance due to the viscous nature of a fluid. Nano emulsion viscosity ranged from 1.842-2.262 mPa.s and Anova test results obtained p value <0.0001 which means independent variable (amplitude, temperature and operating time of sonication) significantly affect the dependent variable (viscosity). The linear regression model of the effect of sonication operation condition on viscosity is as follows :

$$Y_2 = 2.11 - 0.090X_1 - 0.12X_2 + 0.060X_3 \quad (3)$$

Based on the mathematical model can be illustrated that the factor of amplitude and time have negative effect marked with negative constants, on the other hand the temperature factor has positive effect on viscosity (Y_2). The desirable nature of nano emulsion rheology, the negative notation on amplitude and time is desirable to decrease the rheology value, whereas the positive notation at the temperature is undesirable. In other words, to decrease the viscosity of the sonication operation, the amplitude and time value need to be increased while the temperature need to be decreased.

Table 3: Anova regression on energy input and viscosity

Source	Energy input (Y_1)			Source	Viscosity (Y_2)		
	Sum of Squares	F Value	p-value		Sum of Squares	F Value	p-value
Model	236.58	6.37E+07	< 0.0001	Model	0.36	6.37E+07	< 0.0001
A-amplitudo	*98.46*	*6.37E+07*	*< 0.0001*	*A-amplitudo*	*0.11*	*6.37E+07*	*< 0.0001*
B-Time (s)	*138.1*	*6.37E+07*	*< 0.0001*	*B-Time (s)*	*0.2*	*6.37E+07*	*< 0.0001*
C-Temp (C)	*0.022*	*6.37E+07*	*< 0.0001*	*C-Temp (C)*	*0.049*	*6.37E+07*	*< 0.0001*
Residual	0			Residual	0		
Lack of Fit	*0*			*Lack of Fit*	*0*		
Pure Error	*0*			*Pure Error*	*0*		
Cor Total	236.58			Cor Total	0.36		

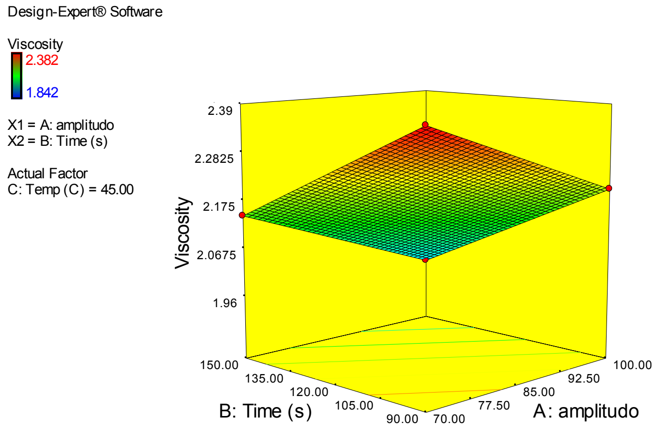

Figure 2. Response surface plot effect of time and amplitude of sonication on viscosity

3.4 Size of droplet diameter

The sonication process per unit time will correlate to the homogeneous properties of the solution and reduce the particle size to a stable nanoscale size and reduce flocculation properties. This condition is caused by shock wave in sonication method can separate agglomeration and there is perfect dispersion with the addition of surfactant as stabilizer.

The size of nanoemulsion droplet diameter ranged 14.123-33.103 nm and anova test results obtained p value <0.0001 which means independent variables (amplitude, temperature and operating time sonicator) significantly the dependent variable (droplet diameter). The linear regression model of the effect of sonication operation condition on droplet size is as follows:

$$Y_3=20.81-3.97X_1-5.34\ X_2-2.98\ X_3 \quad (4)$$

Based on the mathematical model can be illustrated that all free variables negatively affect the droplet size as indicated a negative constants. The smaller droplet size to be more stable the nano emulsions, so the negative notation on the linear regression equation is actually positive. In other words, to decrease the droplet size, the sonication operation is to increase the amplitude, time and operating temperature. The largest value of the constants is at the time of sonication that is 5.34 times, then amplitude 3.97 times, while the temperature gives the smallest effect that is 2.98 times.

According to McClements [12] droplet size is the result of dynamic equilibrium between effects that tend to decrease particle size and the effect that makes the droplet join becomes larger. Droplet size affects the stability of an emulsion. The smaller droplet size makes nano emulsion stable kinetic so as to prevent the occurrence of sedimentation and aggregation during storage.

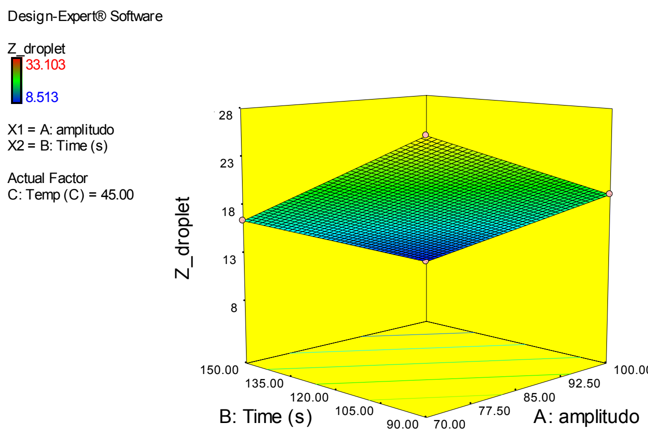

Figure 3. Response surface plot effect of time and amplitude of sonication on sizeof droplet

3.5 Polydispersity Index (PDI)

The PDI of an emulsion is a value that describes the uniformity of the droplet size of an emulsion. The lower the polydispersity value indicates the size of the resulting particles is relatively more uniform. PDI nano emulsion Kawista index ranged from 0.43-0.67 and Anova test results obtained p value <0.0001 which means free variable (amplitude, temperature and operating time of sonication) significantly affect the PDI. The linear regression model of the effect of the sonication operation condition on PDI is as follows:

$$Y_4=0.53-0.060\ X_1-0.060X_2-0.020\ X_3 \quad (5)$$

Based on the mathematical model it can be illustrated that all the independent variables have a negative effect on the PDI. Looking at the linear equations can provide clues that the greater the value of the contest of the independent variables the better the PDI value or the smaller the PDI value representing the more uniform droplet size. The value of the amplitude constant and the sonication operation time are equal to 0.06 times, while the temperature gives that is 0.02 times.

Table 4. Anova droplet size and PDI

Droplet	Source	Sum of Squares	F Value	p-value Prob > F	PDI	Source	Sum of Squares	F Value	p-value Prob > F
	Model	726.50	6.37E+07	< 0.0001		Model	0.100	6.37E+07	< 0.0001
	A-amplitudo	*215.79*	*6.37E+07*	*< 0.0001*		*A-amplitudo*	*0.049*	*6.37E+07*	*< 0.0001*
	B-Time (s)	*389.43*	*6.37E+07*	*< 0.0001*		*B-Time (s)*	*0.049*	*6.37E+07*	*< 0.0001*
	C-Temp (C)	*121.28*	*6.37E+07*	*< 0.0001*		*C-Temp (C)*	*5.46E-03*	*6.37E+07*	*< 0.0001*
	Residual	0.00				Residual	0.000		
	Lack of Fit	*0.00*				*Lack of Fit*	*0.000*		
	Pure Error	*0.00*				*Pure Error*	*0.000*		
	Cor Total	726.50				Cor Total	0.100		

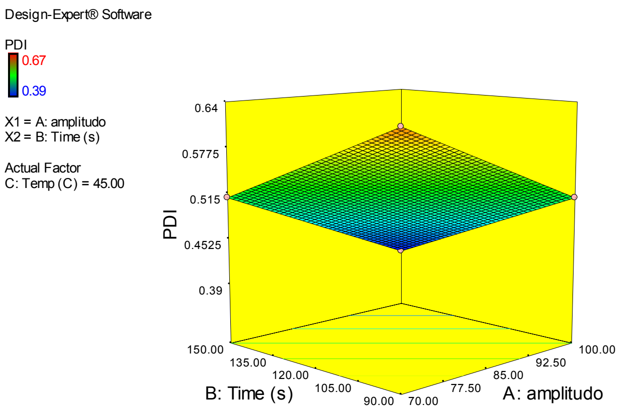

Figure 4. Response surface plot effect of time and amplitude of sonication on PDI

3.6. Optimization of nano emulsion with ultra-sonication

The optimization given to the RSM DX program (Table 5) is based on variable data and response measurement data included with output in the form of recommendations of some optimal new formulas according to the program. The most optimal formula is the formula with maximum desirability value. The range of desirability values is 0 to 1.0, where values closer to 1.0 indicate the ability of the program to produce the desired product more perfectly. The goal of optimization is not to get the value of desirability 1.0, but to find the best conditions that bring together all the purpose functions.

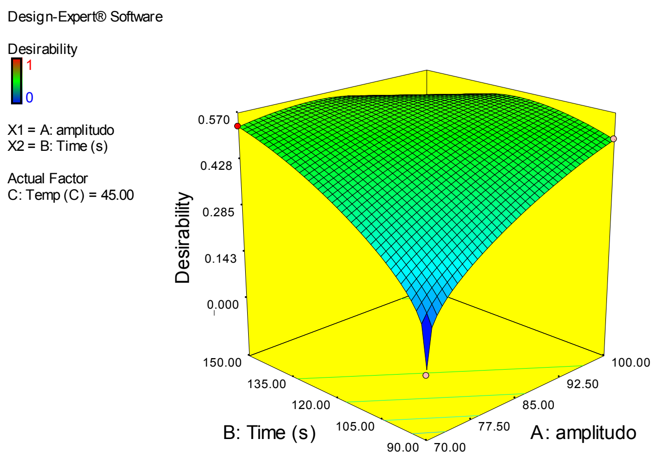

Figure 5. Response surface plot of optimization with time and sonication amplitude

The best formula recommended by DX program it can be seen the Table 6 with desirability value 0.554. It the sonication to use amplitude value, time and temperature are 81.01%, 150s, and 45°C respectively, which will to produce Kawista flavor nano emulsion with energy input, viscosity, droplet size , and the PDI are 15.489J; 2.076 mPa.s; 13.446 nm, and 0.466 respectively. The results obtained from the optimum process conditions are continued to the verification stage, i.e. the processing and analysis of the results in accordance with the best formulation obtained from the optimization of RSM can be seen in the suitability stage verification.

Table 5. Optimization procedure of Kawista flavor extract nano emulsion

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
amplitudo	is in range	70.000	100.000	1	1	3
Time (s)	is in range	90.00	150.000	1	1	3
Temp (C)	is in range	5.000	45.000	1	1	3
Energi	minimize	7.079	18.889	1	1	3
Viscosity	minimize	1.842	2.382	1	1	3
Z_droplet	minimize	8.513	33.103	1	1	3
PDI	minimize	0.390	0.670	1	1	3

Table 6. Optimum formula of Kawista flavor extracts nano emulsion

Solution	amplitude	Time (s)	Temp (C)	Energy	Viscosity	Droplet size	PDI	Desirability	
1	81.01	150.00	45.00	15.4892	2.075955	13.54643	0.465974	0.554516	Selected
2	81.24	149.97	44.97	15.52757	2.074583	13.49515	0.465136	0.554494	
3	81.33	149.52	45.00	15.49568	2.075957	13.54697	0.465651	0.554467	
4	81.06	150.00	44.80	15.49864	2.075022	13.56199	0.465955	0.554455	
5	83.41	146.03	45.00	15.49919	2.077392	13.61538	0.464289	0.554107	
6	81.28	150.00	43.38	15.53442	2.069467	13.71638	0.466512	0.553992	
7	80.99	149.99	43.26	15.48231	2.070848	13.81118	0.46779	0.553963	
8	81.31	150.00	42.94	15.53999	2.067951	13.7714	0.466802	0.553841	
9	81.09	150.00	42.89	15.50028	2.069105	13.83858	0.467744	0.553838	
10	86.08	141.55	45.00	15.50122	2.079333	13.70666	0.462588	0.553628	
11	96.68	124.33	45.00	15.57384	2.084595	13.96195	0.454617	0.551592	
12	99.70	119.25	45.00	15.57488	2.08683	14.06759	0.45272	0.550954	
13	100.00	117.64	20.63	15.40969	2.018345	17.90491	0.479098	0.537719	

4. Conclusion

The development of the method of making nanoemulsion flavor kawista can be done by sonication technique by using RSM for selection of best formula. The results of ANOVA showed a very significant difference ($P<0.0001$) of the sonication condition on the characteristic of kawista nanoemulsion. The higher the sonication state produces higher energy inputs, which is not desired in the manufacture of nanoemulsions. The lower of viscosity nanoemulsion will increase its stability, which can be obtanined through sonication by increasing the amplitude and time, and decreasing the temperature. The higher the value of the sonication condition will decrease the droplet size (nm) and the uniformity of droplet size (the smaller PDI value approaching 0). Small droplet and PDI measurements show nanoemulsion stability and particle uniformity. The best formula (desirability value 0.554) is sonication conditions with amplitude, time and temperature are 81.01%, 150s, and 45^{o}C respectively. Output of nanoemulsions flavor kawista that is energy input, viscosity, droplet size, and PDI i.e. 15,489 J, 2,076 mPa.s, 13,446 nm, and 0,466 respectively.

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