Development, physiochemical and sensory evaluation of a new effhaccpervescent tablet formulation based on Moringa oleifera leaves extract

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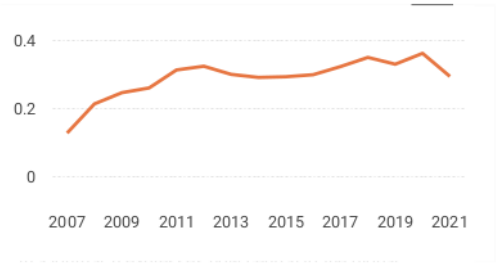

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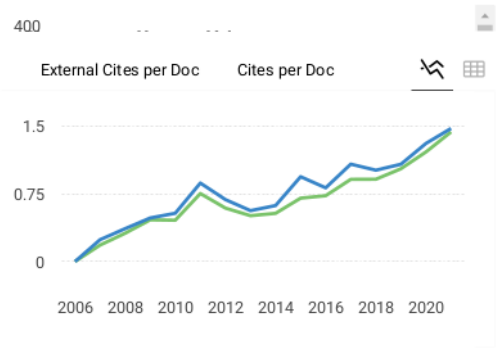

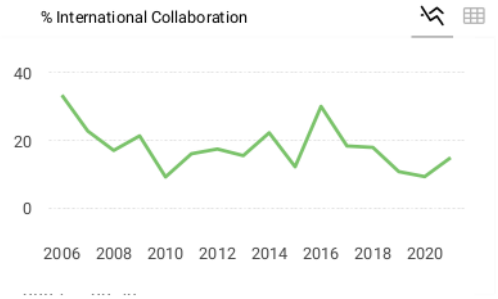

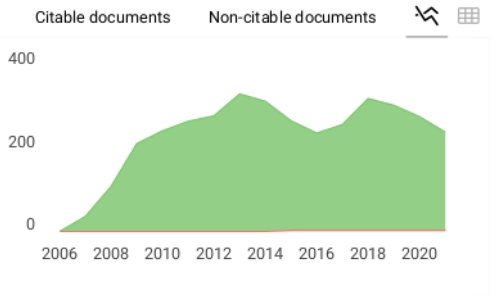

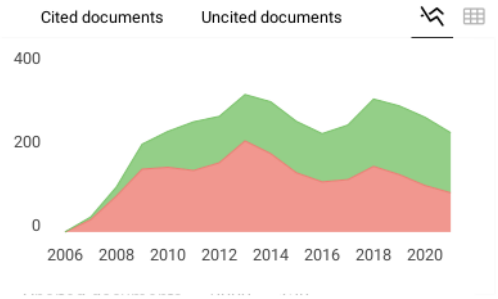

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Development, physiochemical and sensory evaluation of a new effervescent tablet formulation based on *Moringa oleifera* leaves extract

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Abstract: New product development of *Moringa oleifera* effervescent tablet was optimization of the acid-base in the formula by using the D-optimal mix design. Chemical profiling and antioxidant activity of *Moringa oleifera* extract was evaluated. The physicochemical and sensory characteristics of *Moringa oleifera* effervescent tablet was measured. The results shows that chemical compounds of aqueous and ethanol extracts of *Moringa oleifera* extracts were hydrocarbons, esters, alcohols, and fatty acids. Both extracts exhibited high antioxidant by the IC_{50} value at 240.27 µg/mL and 301.21 µg/mL respectively. The quadratic model was found to be the best fitted for evaluating the solubility time, colour, taste and aroma; meanwhile, the special cubic model appeared to be the best fitting model for assessing the hardness response. The optimization process suggested that citric acid (22.19% w/w), tartaric acid (11.17% w/w), and sodium bicarbonate (33.64% w/w) was the best solution for this combination of variables, with a desirability value of 0.798.

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Keywords: acid-base combinations; design D-optimal; effervescent tablet; *Moringa oleifera*.

1 Introduction

Public awareness of the importance of healthy life increase rapidly, thus demand of functional food by consumer was change. Food ingredients which consumers need are not only nutritious, appealing in appearance and taste, but also have particular physiological roles for the human body like reducing blood pressure, cholesterol and blood sugar levels. Food ingredients that have various benefits can be obtained from plants [1].

Moringa oleifera or identified as “Kelor” is one of the plants with a possibility of a medicinal plant. This plant is easy to grow and native to northern India and sub-tropical places, like Asia and Africa. In Asia the plant is generally used as vegetable [2]. Moringa leaves are known to contain phytochemical compounds such as flavonoids, saponins, and tannins that act as antibacterial [3]. Moringa leaves can be used as natural antioxidants by preventing damage caused by free radicals with IC_{50} values ranging from 5.72 to 42.56 g/mL [4].

Various studies have reported the chemical profiling and antioxidant activity of *Moringa oleifera* leaves extract by using different chromatographic techniques [5]. Gas chromatography–mass spectrometry study of the plant’s leaves revealed a total of 35 compound consist of n-hexadecanoic acid, tetradecanoic acid, cis-vaccenic acid, octadecanoic acid, palmitoyl chloride, beta-l-rhamnofuranoside, 5-O-acetyl-thio-octyl, gamma-sitosterol, and pregna-7-diene-3-ol-20-one [6]. It has been reported that climatic factors and stages of maturity could cause variation in distribution of phytochemicals in leaves of *M. oleifera* as well as the choice of solvent as different solvents have different extraction capabilities and spectrum of solubility for phytoconstituents [7]. In this view, the experiment was to evaluate the phytochemical constituents of the aqueous and ethanolic extracts of the *M. oleifera* leaves from West Java-Indonesia.

Effervescent tablets are referred to as tablet planning that can form gas bubbles when mixed with water due to reaction of the acids and bases within them. The resulting bubbles are carbon dioxide, which can create a tingling effect [8]. This type of tablet will be dissolved in water and taken orally in the form of a solution [9]. This preparation is expected to accelerate the initiation of drug action because there is no need to wait for the time to disintegrate [10].

Effervescent tablets contain a mixture of acids and bases. Typically utilised acid sources are citric acid, tartaric acid, and malic acid. Meanwhile, base sources that can be used are sodium bicarbonate, potassium bicarbonate, sodium carbonate, potassium carbonate, and others [11]. According to [12], the component that plays a role in the success of an effervescent tablet is the use of variations of citric acid and tartaric acid [13].

In past studies, citric acid and sodium bicarbonate have been a widely applied combination. The combination of citric acid and sodium bicarbonate in the effervescent affects the dissolution time and pH [14]. Because citric acid is water-soluble and gives food a preferred acidity taste, it is superior to other acid sources [15]. Meanwhile, the use of tartaric acid and sodium bicarbonate was also reported to affect the dissolution time, colour, and hardness of the Temulawak (*Curcuma zanthorrhiza*) effervescent tablets [16].

Linear programming applications can be used to determine the best formulas, one of which is a Design Expert. Design Expert is a program that optimises a product or process with the main reaction is as a result of numerous variables, with the goal of maximising the reaction [17]. The advantage of the *D*-Optimal Design Expert method is the numerical accuracy of the program by 0.001, and the data can be processed quickly and accurately as needed [18]. Desire value is function values for optimization purposes that indicate the program's ability to meet the wishes based on the Criteria set out on the final product. Mark desirability that is close to 1.0 indicates the program's ability to produce perfect enhancing products. Henceforth, this researched intended to use a blended design to analyse the impacts of various concentrations of acid-base, *viz*., citric acid, tartaric acid, and sodium bicarbonate on the physical and sensory properties of Moringa effervescent tablets.

2 Material and methods

2.1 Materials

New *Moringa oleifera* var. Lam leaves were gathered from Kelorina SME's, Pagaden, Subang District, West Java-Indonesia. Citric acid, tartaric acid and sodium bicarbonate were gained from PT. Setia Guna Kimia, Bogor; meanwhile, lactose, aspartame, polyethylene glycol (PEG 4000) were bought from Dwilab Mandiri, Bandung-Indonesia. Aluminum chloride, gallic acid, ethanol, sodium hydroxide, sodium carbonate, Folin-Ciocalteu's phenol, 1,1-dipheynyl 2-picrylhydrazyl (DPPH), and quercetin were obtained from Sigma-Aldrich Pte Ltd., Singapore. Every applied reagent was diagnostic grade.

2.2 Extract preparation

Fresh leaves of *M. oleifera* were cleaned and put to dry at 45–50 °C for 4 h on a tray dryer. The powder was then immersed in distilled water (X_1) or ethanol (X_2) at a ratio of 1:10 (w/v) for 24 h through softening processes (three times). The filtrate was then concentrated, weighed, and dried on a rotary evaporator at 50 °C (Rotavapor R-300 Buchi, Flawil, Switzerland) [19].

2.3 Granules preparation and characterization

The moringa extract powder is mixed with other ingredients according to the formulation. Citric acid, tartaric acid, and sodium bicarbonate were mixed with dry extract, then dried for 30 min at 50 °C and sieved. The refined polyethylene glycol (PEG 4000) was added and molded using a special tablet crushing tool. The moringa effervescent tablets were kept in a closed container and refrigerated at 4 °C until further analysis.

2.3.1 Chemical profiling of moringa extract by GC-MS: The Agilent GC-MS system was employed to detect chemical constituents of moringa extract. The sample injection volume was 1 µL. The Agilent HP-5MS (19091S-433: 93.92873) (Agilent Technology, Inc., J&W Scientific Products, Santa Clara, CA, USA) with 30 m in length, 250 µm internal diameter, and 0.25 µm in thickness was used as column. Helium was chosen as the carrier gas. The mode of helium inlet was splitless with heater temperature of 250 °C, pressure of 70,699 psi, and total flow of 104 mL/min. GC oven temperature's operating condition was remained as follows: The initial temperature = 40 °C with holding time of 1 min, the programmed speed = 10 °C/min up to a final temperature 325 °C with holding time of 4 min. The mass range scanned from 122–1021 amu [20]. The control of the GC-MS system and the data peak processing were carried out using the Agilent ChemStation software.

2.3.2 Antioxidant activity (DPPH assay): The antioxidant activity of moringa leaves extracts was measured by using as documented in the past with a minor modification, the antioxidant activity of the moringa leaf extracts was assessed by applying the 1,1-diphenyl-2-pikrilhidrazil (DPPH) [21]. Conducted by using a spectrophotometer, the calculation against the blank was (SHIMADZU UV-1900, Tokyo, Japan) at wavelength (λ) = 517 nm.

2.4 Experimental design

The initial three acid-base component (citric acid, tartaric acid and sodium bicarbonate) used in this optimization obtained from the literature [22] stated that ratios between all components were determined according to the neutralization of acids and alkali and the allowed amount of each component. *D*-optimal mixture design, which is the optimal formulation for tablets production, was employed in 11 tests

(Table 1) and experimented three times. Evaluation is done by varying the levels of the three components together and maintaining a constant 50% proportion. The physical and sensory characteristics of Moringa effervescent tablets like dissolution time, solidity, colour, taste and scent were chosen as reaction variables.

All reactions (Yi) were made to fit the quadratic mixed model (Equation (1)). On the other hand, the unique cubic model (Equation (2)) seemed to be the best model for evaluating the solidity reaction.

$$Yi = \beta_1 A + \beta_2 B + \beta_3 C + \beta_{12} AB + \beta_{13} AC + \beta_{23} BC \quad (1)$$

$$Yi = \beta_1 A + \beta_2 B + \beta_3 C + \beta_{12} AB + \beta_{13} AC + \beta_{23} BC + \beta_{123} ABC \quad (2)$$

Where Y is the dependent variable (response variable); β_1, β_2, β_3, $\beta 12$, $\beta 13$, β_{23} and β_{123} are the constant coefficients for each linear and interaction term in the predicted models; A, B and C are the levels (proportions) of each pseudo-component (citric acid, tartaric acid and sodium bicarbonate, accordingly). It was discovered that the R^2 values of all response variables were always above 60%. This shows a reasonable amount of variability, as the data reported. The ANOVA findings revealed that all response variables were greatly ($p < 0.05$) affected by the linear terms of the predicted models.

2.4.1 The solubility times: Dissolution time for each formula, 5 tablets were taken to be tested for dissolution time. The tablet is put into a glass containing 200 mL of water and then the tablet dissolution time is calculated using a stopwatch, starting from inserting the tablet into the water until it is completely dissolved [23].

2.4.2 Textural properties (hardness): Using a texture analyser, an analysis of the moringa effervescent tablet's textural aspects were done (TA.XTPlus Stable Micro System, Surrey, UK). The samples were located in the sample area and measured using a P36 probe. The tool setting conditions were pre-test speed 2 mm/s, test speed 1 mm/s, post-test speed 10 mm/s, 30% strain mode, 5 s time and trigger force 5 g. The parameters obtained include hardness (N) [24].

2.4.3 Sensory characteristics: The sensory test, which included colour, scent and texture, was performed by hedonic testing applying the scoring method. The test had gone through six levels from 1 (strongly dislike) to 6 (strongly like). 30 untrained participants were involved in the organoleptic tests. Each treatment was given a different code using numbers as much as three digits with a non-sequential order [25]. Sensory evaluation used to identify areas for development and to determine whether optimizations have been achieved.

2.5 Statistical analysis

Design Expert v.11 (StatEase, USA) was utilised to evaluate the experimental design and fit the responses model. ANOVA analysis followed by Duncan's Multiple Range test enables the variances among groups to be evaluated using R-Statistics 4.03 for Windows. At a significance level of 0.05, it was accounted for statistical variations. Multiple regression analysis was run to produce a polynomial model of variable responses. Corroboration is conducted on the model by examining its significance, lack of fit, and multiple correlation coefficients (R^2). Extract chemical properties were determined by comparing the retention time of the chromatographic peak with WILEY7 database together with NIST library ver.2.0. Moreover, the data obtainable were those that had percent estimation of similarity structure compound (similarity index) ≥ 90% based on WILEY7 and NIST library ver. 2.0.

3 Results and discussion

3.1 Chemical profiling and antioxidant activitiy of moringa extract

Through retention time (RT), molecular weight (MW), molecular formula, and peak area %, the phytochemical components were determined (Tables 2 and 3). The mass spectra of the compounds were matched with WILEY7 and NIST library ver.2.0. Twelve peaks of GC-MS chromatogram of aqueous moringa extract have approximate ≥ 90% percent similarity index with the compound structure (Table 2). The twelve compounds were carbonic acid (9.41%), octadecane (32.28%), octadecyl (4.02%), 1-tetracosene (3.19%), hexatriacontyl pentafluoropropionate (2.73%),

Table 1: Mixture components of the moringa effervescent tablet.

Formulations	Variable levels			Real levels (%)		
	Citric acid *(A)*	Tartaric acid *(B)*	Sodium bicarbonate *(C)*	Citric acid	Tartaric acid	Sodium bicarbonate
1	30.34	17.96	45.50	21.67	12.83	32.50
2	30.34	17.96	45.50	21.67	12.83	32.50
3	30.80	15.63	47.37	22.00	11.16	33.83
4	30.34	16.56	46.90	21.67	10.83	33.50
5	33.14	15.16	45.50	23.67	11.50	32.50
6	31.27	16.10	46.43	22.34	10.83	33.17
7	33.14	15.16	45.50	23.67	10.83	32.50
8	31.74	16.56	45.50	22.67	11.83	32.50
9	30.34	15.16	48.30	21.67	10.83	34.50
10	31.74	15.16	46.90	22.67	10.83	33.50
11	30.80	17.03	45.97	22.00	12.16	32.83

nonacos-1-ene (3.51%), eicosane (4.96%), tetracosane (21.62%), 1-pentacontanol (2.46%), 1-hexacosene (1.67%), triacontane (10.24%), and eicosane, 9-cyclohexyl-(3.89%). Meanwhile, ten peaks GC-MS chromatograms of ethanolic moringa extract is shown in Table 3. The six compounds were 2-pentanol, 2-methyl-acetate (4.17%), eicosyl vinyl ester (12.42%), eicosane (17.97%), docosanoic acid (11.89%), 1,2-benzisothiazol-3-amine 26.44%), and cyclohexane, 1,1′-(2-propyl-1,3-propanediyl)bis-(6.32%). Several compounds were identified such as hydrocarbons (eicosane, tetradecane, and ocatadecane), esters (docosanoic acid, docosyl ester and carbonic acid, eicosyl vinyl ester), and alcohols (2-pentanol, 2-methyl-, acetate and 1-pentacontanol) previously documented by [26].

The antioxidant activity of the *M. oleifera* leaves extract was investigated by the DPPH method. Stated in $IC_{50,}$ the findings of the extracts' antioxidant activity of value are documented in this research. The antioxidant activity of moringa extract is presented in Table 4. The antioxidant activity in the ethanolic extract of moringa leaves was higher than the water extract of moringa leaves. This is indicated by the IC_{50} value obtained which is 240.27 µg/mL and 301.21 µg/mL, respectively. Water and ethanol were used as blanks to avoid solvent interference. The level of discolouration (reduction in absorbance) of the DPPH solution represents the sample antioxidant's scavenging potential during the DPPH free radical reaction. The interaction of DPPH free radicals with antioxidant compounds can be measure through absorption at wavelength 517 nm, the DPPHH formed from the interaction has a lower absorbance than DPPH due to the difference in the number of hydrogen atoms [27]. The bioactive components in the *M. oleifera* extract donated hydrogen to DPPH, changing the colour of the solution [28]. These results were agreement with report of [29] that the highest antioxidant content was obtained from ciplukan fruit extract (*Physalis angulata*) using ethanol as a solvent compared to water extract and ethyl acetate. This study revealed the presence of carbonic acid, eicosyl vinyl ester and eicosane in water and ethanol extracts and were reported to have antioxidant activity by [30]. The presence of 1,2-benzisothiazol-3-amine in ethanol extract in this study might contribute to a higher antioxidant activity and the results was supported by the finding of [31].

Based on the results of profiling and antioxidant activity of *M. oleifera*, further research was conducted using water extract for the formulation of effervescent tablets. This is done by looking at the completeness of the compounds in the water extract and the halal aspects of the products produced.

3.2 Selecting the formulation to be compressed

The effects of the acid-base combinations (citric acid, tartaric acid and sodium bicarbonate) on the contents of physics and sensory characteristics of the effervescent tablet are shown in Table 5. The parameter employed for the model selection was according to the highest coefficient of determination (R^2), with no significant lack of fit. The model was chosen by taking into consideration the parameters were based on the highest coefficient of determination (R^2) and no major lack of fit. The good fit model was obtaining from coefficient *R* square (R^2) at least 80% [17]. In this study, models with R^2 values >80% were used for prediction. Table 5 displays the coefficients. The equations for every response variable could be drawn from the expected values of each response variable.

The constant coefficients corresponding to the effects of citric acid (β_1), tartaric acid (β_2) and sodium bicarbonate (β_3), in the model, β_{12} is coefficient interaction citric acid and

Table 2: Phytochemical components of aqueous extract of *Moringa oleifera* leaves.

No.	Retention time	Area	Peak area (%)	Molecular weight (g/mol)	Molecular formula	Name of compound*
1.	24.6678	41,846,632	9.401	368.60	$C_{23}H_{44}O_3$	Carbonic acid, eicosyl vinyl ester
2.	25.3610	143,692,757	32.281	254.49	$C_{18}H_{38}$	Octadecane
3.	25.9029	17,895,462	4.020	336.60	$C_{24}H_{48}$	Cyclohexane, octadecyl
4.	26.0920	14,241,476	3.199	336.6	$C_{24}H_{48}$	1-Tetracosene
5.	26.2432	12,179,281	2.736	669	$C_{39}H_{73}F_5O_2$	Hexatriacontyl pentafluoropropionate
6.	26.3692	15,645,043	3.515	408.786	$C_{29}H_{60}$	Nonacos-1-ene
7.	26.9742	22,088,964	4.962	282.5	$C_{20}H_{42}$	Eicosane
8.	27.4657	96,242,934	21.621	338.7	$C_{24}H_{50}$	Tetracosane
9.	27.9068	10,949,976	2.460	719.3	$C_{50}H_{102}O$	1-Pentacontanol
10.	28.0454	7,426,383	1.668	364.7	$C_{26}H_{52}$	1-Hexacosene
11.	29.4696	45,583,622	10.24	422.8	$C_{30}H_{62}$	Triacontane
12.	30.0619	17,342,731	3.896	364.7	$C_{26}H_{52}$	Eicosane, 9-cyclohexyl-

*The data has an approximate percent similarity of the compound structure (similarity index) of 90%.

Table 3: Phytochemical components of ethanolic extract of *Moringa oleifera* leaves.

No.	Retention time	Area	Peak area (%)	Molecular weight (g/mol)	Molecular formula	Name of compound*
1.	8.2841	4,850,603	4.176	144.21	$C_8H_{16}O_2$	2-Pentanol, 2-methyl-, acetate
2.	24.7436	14,434,230	12.427	368.6	$C_{23}H_{44}O_3$	Carbonic acid, eicosyl vinyl ester
3.	26.8609	13,814,339	11.893	340.6	$C_{22}H_{44}O_2$	Docosanoic acid, docosyl ester
4.	27.5037	30,710,795	26.44	150.2	$C_7H_6N_2S$	1,2-Benzisothiazol-3-amine
5.	28.4867	20,866,570	17.965	282.5	$C_{20}H_{42}$	Eicosane
6.	29.387	7,341,809	6.321	250.5	$C_{18}H_{34}$	Cyclohexane, 1,1′-(2-propyl-1,3-propanediyl) bis-

*The data has an approximate percent similarity of the compound structure (similarity index) of 90%.

Tabel 4: Antioxidant activity of moringa extract (MoE).

Extract	Nilai IC_{50} (µg/mL)
Water extract (X_1)	301.21 ± 8.29
Ethanolic extract (X_2)	240.27 ± 6.30
Ascorbic acid	37.83

Data presented as average ± standard deviation (s.d) (n = 3).

tartaric acid, β_{13} is coefficient interaction citric acid and sodium bicarbonate, β_{23} is coefficient interaction tartaric acid and sodium bicarbonate, and β_{123} is coefficient interaction citric acid, tartaric acid and sodium bicarbonate. ns: no significant and s: significant at the 5% level ($p < 0.05$).

3.3 Effects of the acid-base combinations mixture on the physics and sensory characteristics on tablet properties

The effects of the different amounts of citric acid, tartaric acid and sodium bicarbonate on the physics and sensory characteristics of the effervescent tablet are presented. Figure 1 presents these response variables' visualisation and contour plots.

3.3.1 Solubility times

Analysis of variance (ANOVA) depicted a significant influence of the formula on the dissolving time's physical response ($p < 0.05$). It means that the response value can be used for the optimization process. The graph of the soluble time response can be seen in Figure 1 at point *A*. The different colours on the contour plot graph show the physical response value to the dissolving time. The red colour shows the longest dissolved time response value, which is 139. The blue colour shows the fastest soluble time response value, which is 53.

3.3.2 Hardness

To determine tablet hardness or solidity, it was mechanically measured as a parameter of the tablets' physical quality. Tablet solidity is one of the quality parameters which

Table 5: The model of the moringa effervescent tablet.

Coefficients	Variable response				
The model	Solubility time (s) Quadratic	Hardness (kgf) Special cubic	Color Special quartic model	Taste Special quartic model	Aroma Special quartic model
Significance of the model (p)	0.0052^s	0.0205^s	0.0295^s	0.3368^{ns}	0.3229^{ns}
Lack of fit of the model	0.5239^{ns}	0.1567^{ns}	–	–	–
R-squared (R^2)	0.9362	0.9391	0.9925	0.9024	0.9071
Adj. R-squared (Adj R^2)	0.8725	0.8478	0.9626	0.5121	0.5356
β_1	79.36	4.87	4.05	3.27	3.43
β_2	137.50	5.05	3.74	3.40	3.68
β_3	61.04	3.87	4.47	3.47	3.60
β_{12}	−222.45	−3.50	0.9500	−2.41	1.25
β_{13}	−29.35	2.34	−1.44	1.73	0.8500
β_{23}	−84.50	−4.36	1.19	−0.4200	−0.6800
B_{123}	–	23.56	–	–	–

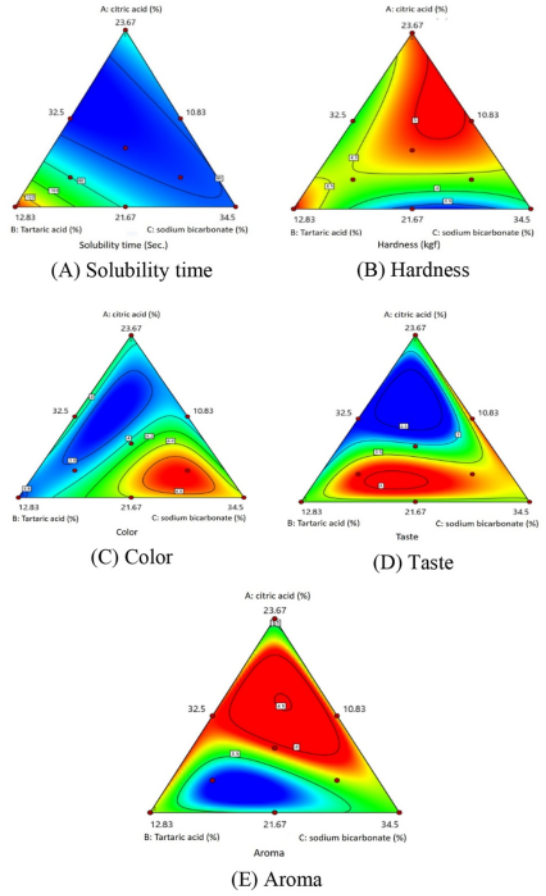

Figure 1: Surface contour plots of the effects of acid-base combinations (*A:* citric acid; *B:* tartaric acid; *C:* sodium bicarbonate) on the physico-chemical and sensory characteristics of the moringa effervescent tablet: (A) solubility time, (B) hardness, (C) color, (D) taste and (E) aroma.

indicates the resistance of the tablet to mechanical troubles. This formula has a great influence on the physical response of the hardness ($p < 0.05$). The graph of the hardness physical response to violence can be seen in Figure 1 at point *B*. The different colours on the contour plot graph show the value of the physical response to hardness. The red colour shows the value of the highest response to hardness (5 kgf). The blue colour shows the lowest value of the response to hardness (3.3 kgf).

3.3.3 Color

The colour assessment in sensory testing has an important role in the level of product visual acceptance [32]. Based on the model results from the hedonic response the colour attribute is a special quartic. The formula has a significant effect on the hedonic response of the colour attribute, so that the response value can be used for the optimization process ($p < 0.05$). The Graph of the colour attribute hedonic response can be seen in Figure 1 at point *C*. The different colours on the contour plot graph show the hedonic response value of the colour attribute. The red colour shows the highest colour attribute hedonic response value (4.73). The blue colour shows the lowest colour attribute hedonic response value (3.7).

3.3.4 Taste

Taste is one of the general criteria that can determine consumer acceptance of a product. Based on the model results from the hedonic response the taste attribute is a special quartic. ANOVA analysis revealed that the formula did not significantly affect the taste response of sensory trait ($p > 0.05$). The contour plot graph of the taste attribute hedonic response can be seen in Figure 1 at point *D*. The different colours on the contour plot graph show the value of the taste attribute hedonic response. The red colour shows the highest taste attribute hedonic response value (3.87). The blue colour shows the lowest taste attribute hedonic response value (2.73). The increase in hardness value of moringa tablet effervescent was influenced by sodium bicarbonate. It is because sodium bicarbonate has the greatest constant value (3.47 °C).

3.3.5 Aroma

ANOVA analysis presented that the formula did not significantly affect the scent response of the sensory trait ($p > 0.05$). The contour plot graph of the aroma attribute hedonic response can be seen in Figure 1 at point *E*. The different colours on the contour plot graph show the hedonic response value for the aroma attribute. The red colour shows the highest hedonic response value for aroma attributes (3.9). The blue colour shows the lowest hedonic response value for aroma attributes (3.23). The aroma of the product is influenced by the presence of aromatic compounds that are carried during the extraction of moringa leaves.

3.4 Optimization of the basic formulation and verification of the model

The ultimate goal of this study was to construct tablet formulation for moringa effervescent. Therefore, during numerical optimisation, the solubility time, hardness, colour hedonic, flavour and scent response were maximised while

other responses and material components were unchanged within range. The responses of melting time and hardness values were given a high relative importance of "5". This is because the effervescent tablets' dissolution time and solidity substances are the most important properties that affect the product quality. The comparative prominence given to the hedonic colour, taste and, scent of the moringa effervescent tablet was '3'. The optimization findings that the moringa effervescent tablet prepared using citric acid (22.19% w/w), tartaric acid (11.17% w/w), and sodium bicarbonate (33.64% w/w) demonstrated the best solution for these combined variables with a desired value of 0.798 (Figure 2).

Three batches of tablets were prepared and characterised to determine quality control values for the technological properties of the tablets (Figure 1). Solid tablets with good mechanical resistance (dissolution time 58 s and hardness 4.34 kgf) were gained. Factors that affect the solubility of a solid in a liquid include stirring intensity, pH (acidity), temperature, liquid solvent composition, particle size, the effect of surfactants, complex formation, and pressure [15]. The longer the carbon atoms chain, the lower the polarity, which results in reduced solubility in water. The number of hydroxyl groups can increase the solubility in water. The solubility time is related to the porosity of the granules [33]. The greater the porosity of a granule, the larger the voids between particles. This condition facilitates more rapid entry of liquid into the granule structure and encourages the granules to disintegrate.

According to the United States Pharmacopeia (USP), effervescent tablets must have a hardness level ranging from 4–9 kgf. All formulas have very good hardness values because they are still above the specified limit, which is at least 4 kgf. The tablet hardness is influenced by, among others, the amount of pressure during compression, the nature of the compressed material, the type and concentration of the binder used and the condition of the granules [34].

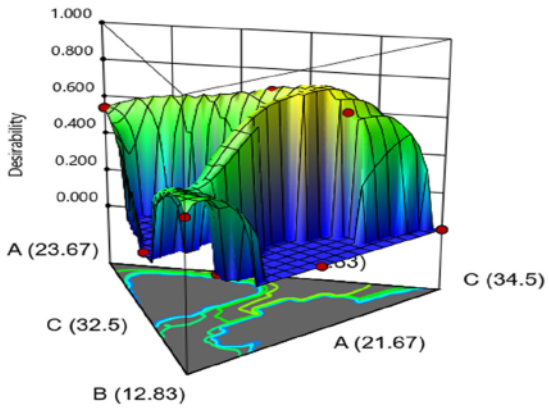

Figure 2: Optimal 3D Formula Graphics. X1 = citric acid, X2 = tartaric acid, X3 = sodium bicarbonate.

The addition of sodium bicarbonate will affect the colour. It is because when sodium bicarbonate dissolves in water, the soda gives a clearer effect. Soda-like taste is a characteristic of [14]. The combination of citric acid and sodium bicarbonate is very influential in the formation of CO_2 gas which gives a sparkle effect.

According to the findings in Figure 2, moringa effervescent tablets were manufactured using this formula and all response variables of the final product were examined. The expected response values were compared to the experimental values for each response using the model equations. The predicted response values were solubility time of 58 s, solidity of 4.34 kgf, colour of 4.73, taste of 3.67 and scent of 3.67. The experimental response values were solubility time of 73 s, solidity of 4.5 kgf, colour of 4.75, taste of 3.70, and aroma of 3.70. The experimental and predicted data's response values were within the confidence and prediction intervals. This shows that the model can be applied to optimise the fundamental formulation of effervescent tablet for the acid-base mixture. Finished moringa effervescent tablets must possess exceptional technical characterisation quality, but also maintain the effectiveness and pharmacological effect of the drug to ensure efficacy and safety.

4 Conclusions

In conclusion, a total of 12 chemical compounds from aqueous extracts and 10 compounds from ethanol extracts which were classified as hydrocarbons, esters, alcohols, and fatty acids were identified by GC-MS analysis. Both two extracts exhibited high antioxidant by the IC_{50} value at 240.27 µg/mL and 301.21 µg/mL. The findings revealed that the quadratic model was optimal for assessing the solubility time, colour, taste, and scent. On the other hand, the unique cube model seemed to be the most suitable model for evaluating the solidity response. The *Mixture D-Optimal* design approach was greatly utilised to gain the best acid-base blend, *viz*., citric acid, tartaric acid, and sodium bicarbonate. A combination of citric acid (22.19% w/w), tartaric acid (11.17% w/w) and sodium bicarbonate (33.64% w/w) resulted in an optimum moringa effervescent tablet formulation. The desired value for the optimal formulation was 0.798. This formulation was able to offer solubility time (73 s), solidity (4.5 kgf), colour (4.75), taste (3.70), and scent (3.70).

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References

1. Sharopov F, Braun MS, Gulmurodov I, Khalifaev D, Isupov S, Wink M. Antimicrobial, antioxidant, and anti-inflammatory activities of essential oils of selected aromatic plants from Tajikistan. Foods 2015;4:645–53.
2. Sultana S. Nutritional and functional properties of *Moringa oleifera*. Metabolism Open 2020;8:100061.
3. Moyo B, Masika PJ, Muchenje V. Antimicrobial activities of *Moringa oleifera* Lam leaf extracts. Afr J Biotechnol 2012;11:2797–802.
4. Unuigbe CA, Okeri HA, Erharuyi O, Oghenero EE, Obamedo DA. Phytochemical and antioxidant evaluation of *Moringa oleifera* (Moringaceae) leaf and seed. J Pharm Bioresour 2014;11:51–7.
5. Bhattacharya A, Tiwari P, Sahu PK, Kumar S. Sciences b: a review of the phytochemical and pharmacological characteristics of *Moringa oleifera*. J Pharm BioAllied Sci 2018;10:181.
6. Bhattacharya A, Ghosh G, Agrawal D, Sahu P, Kumar S, Mishra S. GC-MS profiling of ethanolic extract of *Moringa oleifera* leaf. Int J Pharm Biol Sci 2014;5:263–75.
7. Bamishaiye E, Olayemi F, Awagu E, Bamshaiye O. Proximate and phytochemical composition of Moringa oleifera leaves at three stages of maturation. Adv J Food Sci 2011;3:233–7.
8. Dharma Utama M, Chotimah C, Achmad H, Arifin F, Winaya Furqani A. Effect of solvent temperature in effervescent granule denture cleanser with cacao pod (theobroma cacao l) 6, 5% toward the growth of *Streptococcus mutans* and *Candida albicans*. Ann RSCB 2021;25:10858–64.
9. Saifullah M, Yusof Y, Chin N, Aziz M. Physicochemical and flow properties of fruit powder and their effect on the dissolution of fast dissolving fruit powder tablets. Powder Technol 2016;301:396–404.
10. Saifullah M, Yusof Y, Chin NL, Aziz M, Mohammed M, Aziz N. Dissolution profiling and its comparison of natural fruit powder effervescent tablets. J Food Eng 2016;178:60–70.
11. Surini S, Wardani MRW, Sagita E. Evaluating of effervescent tablets containing grape seed (Vitis vinifera L.) extract as a nutraceutical. Int J Appl Pharm 2017;9:150–3.
12. Anova IT, Kamsina K, Hermianti W. Formulasi perbandingan asam basa serbuk effervescent Dari coklat bubuk. Jurnal Litbang Industri 2016;6:99–106.
13. Anwar K. Formulasi sediaan tablet effervescent Dari ekstrak kunyit (*Curcuma domestica* Val.) dengan variasi jumlah asam sitrat-asam tartrat sebagai sumber asam. Jurnal Sains Terapan Kimia 2010;4:168–78.
14. Lingga D. The effect of citric acid and sodium bicarbonate concentration on the quality of effervescent of red ginger extract. In: IOP conference series: earth and environmental science: IOP Publishing; 2019:012022 p.
15. Daneshfar A, Baghlani M, Sarabi RS, Sahraei R, Abassi S, Kaviyan H, et al. Solubility of citric, malonic, and malic acids in different solvents from 303.2 to 333.2 K. Fluid Phase Equil 2012;313:11–5.
16. Kuswardhani N, Belgis M, Tiara A. Characterization of physical and chemical properties of effervescent tablets Temulawak (*Curcuma zanthorrhiza*) in the various proportion of sodium bicarbonate and tartaric acid. In: E3S web of conferences: EDP Sciences; 2020:03006 p.
17. Baş D, Boyacı IH. Modeling and optimization I: usability of response surface methodology. J Food Eng 2007;78:836–45.
18. Kuram E, Ozcelik B, Bayramoglu M, Demirbas E, Simsek BT. Optimization of cutting fluids and cutting parameters during end milling by using D-optimal design of experiments. J Clean Prod 2013;42:159–66.
19. Iwansyah AC, Manh TD, Andriana Y, Aiman bin Hessan M, Kormin F, Cuong DX, et al. Effects of various drying methods on selected physical and antioxidant properties of extracts from *Moringa oliefera* leaf waste. Sustainability 2020;12:8586.
20. Enerijiofi KE, Akapo FH, Erhabor JO. GC–MS analysis and antibacterial activities of *Moringa oleifera* leaf extracts on selected clinical bacterial isolates. Bull Natl Res Cent 2021;45:1–10.
21. Yusoff MM, Iwansyah AC. Comparative evaluation of total phenolics and free radical scavenging activity of aqueous extracts of *Labisia pumila* var. alata from Malaysia and Indonesia. In: Proceeding of 2nd international conference on biotechnology and food science (ICBFS 2011); 2011:4–8 pp.
22. Aslani A, Jahangiri H. Formulation, characterization and physicochemical evaluation of ranitidine effervescent tablets. Adv Pharmaceut Bull 2013;3:315.
23. Aslani A, Daliri A. Design, formulation and evaluation of its physiochemical properties of acetaminophen, ibuprofen and caffeine as effervescent tablet. J Rep Pharm Sci 2016;5:122.
24. Lukman I, Nurul H, Noryati I. Physicochemical and sensory properties of commercial chicken nuggets. Asian J Food Agro-Ind 2009;2:171–80.
25. Solichah E, Iwansyah AC, Pramesti D, Desnilasari D, Agustina W, Setiaboma W, et al. Evaluation of physicochemical, nutritional, and organoleptic properties of nuggets based on moringa (*Moringa oleifera*) leaves and giant catfish (Arius thalassinus). Food Sci Technol 2021;42:1–6.
26. Al-Owaisi M, Al-Hadiwi N, Khan SA. GC-MS analysis, determination of total phenolics, flavonoid content and free radical scavenging activities of various crude extracts of *Moringa peregrina* (Forssk.) Fiori leaves. Asian Pac J Trop Biomed 2014;4:964–70.
27. Baliyan S, Mukherjee R, Priyadarshini A, Vibhuti A, Gupta A, Pandey RP, et al. Determination of antioxidants by DPPH radical scavenging activity and quantitative phytochemical analysis of Ficus religiosa. Molecules 2022;27:1326.

28. Kitima S, Souksanh N, Yupaporn S. Paperbased DPPH assay for antioxidant activity. Anal Sci 2018;34:795–800.
29. Kusumaningtyas R, Laily N, Limandha P. Potential of ciplukan (*Physalis angulata* L.) as source of functional ingredient. Procedia Chem 2015;14: 367–72.
30. Rhetso T, Shubharani R, Roopa M, Sivaram V. Chemical constituents, antioxidant, and antimicrobial activity of Allium chinense G. Don. Future J Pharm Sci 2020;6:1–9.
31. Sofidiya MO, Bamigbade O, Basheeru K, Adegoke O, Agunbiade FO, Spices, et al. Chemical composition, gastroprotective, and antioxidant activities of *Schrebera arborea* fruits. J Herbs Spices Med Plants 2020;26: 89–100.
32. Syamsul ES, Supomo S. Formulation of effervescent powder of water extract of bawang tiwai (Eleuterine palmifolia) as a healthy drink. Majalah Obat Tradisional 2014;19:113–7.
33. Moroney KM, Vynnycky M. Mathematical modelling of drug release from a porous granule. Appl Math Model 2021;100:432–52.
34. Akdag Y, Gulsun T, Izat N, Cetin M, Oner L, Sahin S. Characterization and comparison of deferasirox fast disintegrating tablets prepared by direct compression and lyophilization methods. J Drug Deliv Sci 2020;57:101760.

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