Research of Service Administration Health and Sains Healthys
Vol. 7 No. 3 September 2026
*p-ISSN:*2830-4748 e-ISSN: 2830-4772
DOI: *10.58258/rehat.v7i3.11489/ http://ejournal.mandalanursa.org/index.php/Rehat*

Formulation and Antioxidant Activity Test of Effervescent Granules of Red Dragon Fruit Peel Extract (*Hylocereus Polyrhizus W.*) And Lime Peel (*Citrus Aurantifolia S.*) With the DPPH Method

Dian Putri Maharani[1], Tatiana Siska Wardani[2], Anita Dwi Septiarini[3]
Program Studi Sarjana Farmasi, Fakultas Ilmu Kesehatan, Universitas Duta Bangsa Surakarta, Indonesia

Article Info
Article history:
Accepted: 17 September 2026
Publish: 23 September 2026

Keywords:
Effervescent Granule;
Red Dragon Fruit Peel;
Lime Peel;
Antioxidant;
DPPH Method.

Abstract
Excessively formed free radicals trigger oxidative stress and various degenerative diseases, so the body requires an intake of exogenous antioxidants. Red dragon fruit peel (Hylocereus polyrhizus W.) and lime peel (Citrus aurantifolia S.) are agricultural wastes containing flavonoids, phenolic compounds, and vitamin C, giving them potential as natural antioxidants, although their utilization remains limited. This study aimed to formulate a combination of both extracts into an effervescent granule and to evaluate its physical quality and antioxidant activity using the DPPH method. Granules were prepared in four formulas (F1-F4) with total extract concentration variations of 0%, 2%, 3%, and 4% (extract ratio 1:1) using the wet granulation method, then evaluated for organoleptic properties, flow rate, angle of repose, dissolving time, pH, moisture content, hedonic test, and physical stability. Antioxidant activity was determined based on the IC50 value using a UV-Vis spectrophotometer at a wavelength of 516 nm. The results showed that all formulas met the physical quality requirements of a good effervescent granule. The IC50 values of F1, F2, F3, and F4 were 9.715, 7.540, 12.721, and 8.163 ppm respectively, all classified as very strong antioxidants (IC50 <50 ppm). Formula 2, containing 1% of each extract, was proven to be the best formula with the highest antioxidant activity. This study demonstrates that the combination extract of red dragon fruit peel and lime peel can be developed into a functional effervescent granule that meets physical quality standards and possesses very strong antioxidant activity.

Corresponding Author:
Dian Putri Maharani
Program Studi Sarjana Farmasi, Universitas Duta Bangsa Surakarta.
Email: dianputri.maharani@gmail.com

1. INTRODUCTION

Free radicals are molecules or atoms that have an unpaired electron in their outermost orbit, making them highly reactive and unstable. These compounds can form endogenously through cellular metabolism or originate from exogenous factors such as air pollution, radiation, ultraviolet light, and various environmental toxins. When present in excessive amounts, free radicals can cause oxidative stress that damages lipids, proteins, and DNA, potentially triggering various degenerative diseases. Therefore, exogenous antioxidants are needed to neutralize free radicals by donating electrons, thus protecting cells and tissues from oxidative damage [1].

One source of natural antioxidants that has great potential is red dragon fruit skin (*Hylocereus polyrhizus W.*), agricultural waste that has been underutilized despite

containing anthocyanin pigments and other bioactive compounds such as alkaloids, flavonoids, terpenoids, tannins, saponins, and vitamins C and E that play a role in antioxidant activity. Phenolic and flavonoid compounds in red dragon fruit skin are known to make an important contribution in warding off free radicals through radical scavenging mechanisms and inhibiting oxidative reactions [2].

Besides red dragon fruit, lime (*Citrus aurantifolia S.*) is also known to have antioxidant activity through its flavonoid and vitamin C content. The use of lime in society is still limited to the leaves and juice, while the skin of the fruit is relatively rarely used and often ends up as waste, even though it is known to contain bioactive compounds that have the potential to act as antioxidants, anti-irritants, anti-inflammatory, antibacterial, and antiseptic [3].

Effervescent preparations are dosage forms containing acidic and basic components (carbonate or bicarbonate) that react to produce carbon dioxide gas when dissolved in water, thus creating a refreshing sensation due to carbonation. This dosage form has the advantages of being easy to consume, being able to mask the unpleasant taste of the active ingredient, and accelerating the absorption of the active substance because it has been dispersed in water before consumption [4].

The DPPH (2,2-diphenyl-1-picrylhydrazyl) method is a commonly used method to evaluate the antioxidant activity of a compound. DPPH is a stable, deep purple free radical with maximum absorption at a wavelength of around 517 nm. The principle of this test is based on the ability of antioxidant compounds to reduce DPPH free radicals, which is indicated by a color change from purple to paler, then measured quantitatively using a UV-Vis spectrophotometer and expressed in IC50 values, namely the concentration of the compound needed to inhibit 50% of DPPH free radicals [1].

Several previous studies reported the antioxidant activity of red dragon fruit peel extract using the DPPH method with varying IC50 values, namely 2.6949 ppm [5], 9.16 ppm [6], and 3.14 g/100 ml [7], all of which are classified as very strong. Similarly, in lime peel, IC50 values were reported at 5.81 µg/ml [8], 54.458 µg/ml [9], and 37.92 ppm [10]. Variations in IC50 values between studies are influenced by differences in extraction methods, maceration duration, and geographic origin of the samples.

Previous research on the antioxidant activity of effervescent granules of red dragon fruit peel extract using the DPPH method is generally still limited to testing one type of extract individually and has not been widely developed in the form of a practical combination of pharmaceutical preparations [11]. Based on this description, this study was conducted to formulate a combination of red dragon fruit peel extract and lime peel into an effervescent granule preparation and evaluate its physical quality and antioxidant activity using the DPPH method, with the hope of obtaining an optimal formula that utilizes both fruit peel wastes synergistically and provides added value in the form of a practical functional food product for consumption.

The objectives of this study were: (1) to determine whether the combination of red dragon fruit peel extract and lime peel can be formulated into an effervescent granule preparation that meets physical quality standards; (2) to determine the antioxidant activity of the effervescent granule preparation using the DPPH method; and (3) to determine the best formula that shows the highest antioxidant activity among the variations in extract concentrations tested.

2. RESEARCH METHOD

This research is an experimental laboratory study that aims to formulate and evaluate the physical quality and antioxidant activity of effervescent granule preparations from a

combination of red dragon fruit peel extract (*Hylocereus polyrhizus W.*) and lime peel (*Citrus aurantifolia S.*) using the DPPH method. A series of procedures was carried out systematically, starting with sample procurement and plant identification, followed by the preparation of simple drugs and extraction, phytochemical screening, effervescent granule formulation, physical quality testing, and ending with antioxidant activity testing. The research was conducted for three months (May-July 2026) at the Natural Materials Laboratory, Faculty of Health Sciences, Duta Bangsa University, Surakarta, and obtained ethical clearance from Muhammadiyah University of Purwokerto as a form of respect for the ethical principles of health research involving human respondents in hedonic tests [12].

The tools used include laboratory glassware, blender, rotary evaporator, analytical balance, oven, water bath, mortar and pestle, mesh sieve, furnace, micropipette, UV-V is spectrophotometer, moisture analyzer, pH meter, flow tester, and stopwatch. The materials used include red *dragon* fruit peel, lime peel, sodium bicarbonate, citric acid, tartaric acid, polyvinylpyrrolidone (PVP), sodium carboxymethyl cellulose (Na-CMC), mannitol, sodium benzoate, 70% ethanol, and p.a. DPPH powder, vitamin C, and distilled water.

2.1 Preparation of Simplicia and Extract

Red dragon fruit peel was obtained from the Mojolaban area and lime peel from the Bendosari area, Sukoharjo, Central Java. Plant identification was carried out at the UPF Yankestrad RSUP Dr. Sardjito, Karanganyar, to ensure the authenticity of the plant identity. Both materials were wet-sorted, washed, dried (dried in the sun covered with a black cloth followed by oven drying at 50°C), then ground and sieved with a 20 mesh to obtain a simple powder. Standardization of the simple includes determining drying loss, water content, and ash content, referring to the requirements of the Indonesian Herbal Pharmacopoeia [13].

Extraction was carried out using the maceration method with 70% ethanol solvent at a ratio of simplicia powder to solvent of 1:10 for 3×24 hours. The filtrate obtained was filtered, then evaporated using a rotary evaporator and continued in a water bath at a temperature of 60°C until a thick extract was obtained. The extract obtained was then standardized (water content, ethanol-free test, and metal contamination) according to the requirements of the Indonesian Food and Drug Supervisory Agency (BPOM RI) [14], and tested for phytochemical screening (alkaloids, flavonoids, saponins, and tannins) using the color reaction method.

2.2 Effervescent Granule Formulation

Effervescent granule preparations were formulated in four formulas with variations in total extract concentration, namely F1 (without extract/basic formula control), F2 (1% red dragon fruit peel extract + 1% lime peel extract), F3 (1.5% + 1.5%), and F4 (2% + 2%) with the ratio of the two extracts kept at 1:1, as presented in Table 1. The composition of the reference formula was adapted from Toding's research. *et al.*[11] with the modification of adding sodium benzoate as a preservative.

Table 1. Effervescent Granule Formula Combination of Red Dragon Fruit Peel Extract and Lime Peel

Material	Function	F1 (%)	F2 (%)	F3 (%)	F4 (%)
Red dragon fruit peel extract	Active ingredients	-	1	1,5	2
Lime peel extract	Active ingredients	-	1	1,5	2
Sodium bicarbonate	Base components	25	25	25	25
Citric acid	Acid components	11	11	11	11
Tartaric acid	Acid components	14	14	14	14
PVP	Fastener	2	2	2	2

Material	Function	F1 (%)	F2 (%)	F3 (%)	F4 (%)
Na-CMC	Thickening agent	1	1	1	1
Natrium benzoat	Preservative	0,1	0,1	0,1	0,1
Dye	Dye	-	qs	qs	qs
MANNITOL	Sweeteners and fillers	ad 100	ad 100	ad 100	ad 100

Granules were manufactured using a wet granulation method with a separate granulation approach between the base and acid components. The base components (sodium bicarbonate, mannitol, Na-CMC, PVP, dye, and sodium benzoate) were dissolved in ethanol, stirred homogeneously, granulated with a 16-mesh sieve, and dried in an oven at 60°C for 15 minutes. The acid components (citric acid, tartaric acid, dye, and both dry extracts) were processed in a similar manner. The two dry granules were then mixed and sieved with a 20 mesh before undergoing a series of physical quality tests [15].

2.3 Evaluation of Physical Quality and Stability of Granules

Physical quality evaluation includes: (a) organoleptic test (color, odor, taste); (b) flow rate and angle of repose test using the funnel method, with the criteria for good flow rate if the flow time of 100 g is ≤10 seconds and the angle of repose is ≤40° [15]; (c) dissolution time test, with the condition that it dissolves completely in 1-2 minutes [11]; (d) pH test using a pH meter, with the condition that the pH is close to neutral (5-7) [16]; (e) water content test using a moisture analyzer at a temperature of 105°C, with the condition that the maximum is 4% [17]; and (f) hedonic test (preference test) on 20 panelists who assess the parameters of color, odor, taste, and freshness using a numerical scale of 1-5 [18]. The physical stability test was carried out using the method of *cycling test* as many as 4 cycles, namely storage at a temperature of 4°C±2°C for 24 hours followed by a temperature of 40°C±2°C for 24 hours, then the organoleptic changes were evaluated [19].

2.4 Antioxidant Activity Test Using DPPH Method

The antioxidant activity test begins with determining the maximum wavelength of the DPPH solution in the range 400-600 nm and determining the *reaction time* to ensure a stable reaction time between the sample and the DPPH radical [21]. The test solution was prepared in a series of concentrations of 1, 5, 10, and 15 ppm for every single extract and granule preparation, with vitamin C (2, 4, 6, and 8 ppm) as a positive control. A total of 4 mL of DPPH solution was reacted with 50 µL of the test solution, incubated for 30 minutes in the dark, and then the absorbance was measured at the maximum wavelength using a UV-Vis spectrophotometer.

2.5 Data Analysis

The inhibition percentage was calculated using the equation: %Inhibition = [(A control - A sample) / A control] × 100%, where A control is the absorbance of the DPPH solution without sample and A sample is the absorbance of the solution after the reaction [20]. The concentration (x) and percent inhibition (y) values were plotted in a linear regression equation y = ax + b, then the IC50 value was determined by substituting y = 50 into the equation IC50 = (50-b)/a. The data obtained were analyzed descriptively and categorized based on the strength of the antioxidant activity, namely very strong (IC50 <50 ppm), strong (50-100 ppm), moderate (100-150 ppm), and weak (150-200 ppm).

3. RESULTS AND DISCUSSION

This section presents the results of research on the formulation and physical quality testing of effervescent granules using a combination of red dragon fruit peel and lime peel extracts, as well as the results of antioxidant activity testing using the DPPH method, which are discussed comprehensively in subsection 3.2.

3.1 Research Results

Plant determination carried out at UPF Yankestrad RSUP Dr. Sardjito identified the sample as red dragon fruit (*Hylocereus polyrhizus W.*) from the family *Cactaceae* and lime (*Citrus aurantifolia S.*) from the family *Rutaceae*, so that the authenticity of the raw material identity can be scientifically accounted for. The yield results of the red dragon fruit peel and lime peel simplicia were 11.5% and 27.2%, respectively, while the results of the standardization of the simplicia and extract are presented in Table 2.

Table 2. Results of Standardization of Simplex and Extract (Mean ± SD)

Parameter	Red Dragon Fruit Skin	Lime Peel	Conditions	Reference
Drying shrinkage of simple drugs	3,20% ± 0,01%	5,42% ± 0,21%	<10%	[13]
Water content of simple drugs	4,03% ± 0,20%	7,10% ± 0,24%	<10%	[14]
Ash content of simple drugs	0,61%	0,13%	<10,2%	[13]
Extract yield	12,8%	10,4%	>10%	[13]
Extract water content	1,25%	1,25%	<10%	[14]
Ethanol free	No ester odor	No ester odor	No ester odor	[13]
Metal contamination	Does not change color	Does not change color	Does not change color	[16]

The results of phytochemical screening showed that both extracts gave negative results for the *alkaloid* group, but were positive for flavonoids, saponins, and tannins, as presented in Table 3.

Table 3. Phytochemical Screening Results of Red Dragon Fruit Peel and Lime Peel Extracts

Compound Groups	Reagent/Indicator	Red Dragon Fruit Skin	Lime Peel	Reference
Alkaloid	HCl + Mayer's reagent	(-)	(-)	[6]
Flavonoid	Aquadest + Mg + concentrated HCl	(+)	(+)	[28]
Saponin	Hot water (foam test)	(+)	(+)	[6]
Land	FeCl3 1%	(+) blackish blue	(+) blackish green	[6]

The evaluation of the physical quality of effervescent granules of the combination of red dragon *fruit* peel and lime peel extracts in the four formulas is presented briefly in Table 4. The organoleptic test results show that the intensity of the pink color, the distinctive aroma of the extract, and the sour taste increase in line with the increase in extract concentration from F1 to F4.

Table 4. Summary of Physical Quality Test Results of Effervescent Granules (Mean ± SD)

Parameter	F1	F2	F3	F4	Conditions
Flow rate (g/s)	3,45±0,96	5,29±1,10	4,25±1,76	8,50±0,61	≤10 seconds
Angle of repose (°)	22,25±1,49	24,32±1,29	22,80±1,60	26,37±1,05	≤40°
Dissolving time (minutes)	1,15±0,14	1,10±0,05	1,13±0,05	1,09±0,06	1-2 minutes
pH	5,88±0,17	5,92±0,18	6,01±0,31	6,14±0,17	5-7
Water content (%)	2,38±0,93	2,40±0,53	1,42±0,48	1,73±1,11	≤4%
Hedonic test (%)	71,5	76,25	81,75	80,5	-

Physical stability test using the method of *cycling test* for 4 cycles showed that all formulas maintained consistent color, distinctive odor, and sour taste, but experienced changes in shape in the form of *granule* clumping in all formulas due to water vapor absorption during testing.

The maximum wavelength of the DPPH solution was determined at 516 nm with an absorbance of 0.613 [22], and the *operating time w*as set at 4 minutes. The results of the antioxidant *activity* test are presented in Table 5. Vitamin C as a positive control showed an IC50 value of 18.015 ppm. The single extract of red dragon fruit peel had an IC50 of 10.462 ppm, and the single extract of lime peel was 13.951 ppm. As a commercial comparison, chrysanthemum flower-based herbal granules (*Chrysanthemum morifolium*) showed an IC50 of 21.271 ppm. The IC50 values of the four effervescent granule combination formulas were F1 9.715 ppm; F2 7.540 ppm; F3 12.721 ppm; and F4 8.163 ppm, with Formula 2 showing the highest antioxidant activity (lowest IC50 value) among all samples tested.

Table 5. IC50 Values of Vitamin C, Single Extract, Commercial Comparator, and Effervescent Granules

Sample	IC50 (ppm)	Category	Reference
Vitamin C (positive control)	18,015	Very strong	[23]
Red dragon fruit peel extract	10,462	Very strong	[24]
Lime peel extract	13,951	Very strong	[24]
Chrysanthemum Granules (comparison)	21,271	Very strong	[27]
Formula 1 (0% extract)	9,715	Very strong	-
Formula 2 (1% + 1%)	7,540	Very strong	-
Formula 3 (1,5% + 1,5%)	12,721	Very strong	-
Formula 4 (2% + 2%)	8,163	Very strong	-

3.2 Discussion

a. Plant Determination and Raw Material Preparation

Determination aims to match the morphological characteristics of the plant with reference literature to avoid misidentification of research raw materials. The results of the determination ensure that the samples used are indeed *Hylocereus polyrhizus* W. and *Citrus aurantifolia S.*, so that the validity of the resulting data can be scientifically accounted for. The wet sorting, washing, and drying processes aim to reduce the initial water content while preventing microbial growth that can damage the active compound content during storage, while the refining stage aims to increase the contact surface area between the simple drug and the solvent so that the secondary metabolite extraction process becomes more effective.

b. Standardization of Simplicia and Extracts

The drying shrinkage and water content parameters describe the number of volatile compounds and water residue remaining after the drying process. The drying shrinkage values of red dragon fruit peel (3.20%) and lime peel (5.42%) and the water content of the simplicia of 4.03% and 7.10%, respectively, are below the maximum limit of 10% required [13], [14]. Water content that is too high (≥10%) has the potential to trigger enzymatic reactions and the growth of microorganisms that can reduce the stability and quality of the simplicia during storage. Likewise, low ash content (0.61% and 0.13%) indicates that the internal mineral content and external contaminants are within normal limits, indicating that the raw material is free from excessive inorganic contamination.

Extraction was carried out using the maceration method using 70% ethanol because it is a semipolar solvent that is effective in attracting polar to semipolar flavonoid and phenolic compounds without damaging the compound structure due to heat, as occurs in the hot extraction method. The yield of red dragon fruit peel extract (12.8%), which is higher than

lime peel (10.4%), indicates the content of secondary metabolites that are more soluble in ethanol in the material. The results of extract standardization showed a water content of 1.25% in both extracts, was free from residual ethanol (marked by no ester odor), and no metal contamination was detected, so that the resulting extract has met the quality requirements as a raw material for pharmaceutical preparations [14].

c. Phytochemical Screening

Negative results for the alkaloid group are likely due to the low alkaloid content in the fruit skin compared to the seeds or leaves of the plant. Positive flavonoid results are indicated by a red color change after the addition of Mg powder and concentrated HCl, where the flavonoid carbonyl group binds with Mg to form a red-orange flavylium salt [28]. Positive saponin results are indicated by the formation of stable foam due to a decrease in the surface tension of water by the glycoside group, while positive tannin results are indicated by a blue-black to blackish-green color change due to the formation of a complex compound between the phenolic group of tannin and the Fe3+ ion from FeCl3. The presence of flavonoids, saponins, and tannins in both extracts supports their potential as a source of natural antioxidants because all three groups of compounds have hydroxyl groups that can donate hydrogen atoms to stabilize free radicals.

d. Effervescent Granule Formulation

The wet granulation method was chosen because it can improve the cohesiveness and compressibility of the powder, provide a more uniform distribution of the active substance content, and prevent the separation of the mixture components during the production process [15]. A combination of citric acid and tartaric acid was used as an acid source because the use of citric acid alone tends to produce a sticky mass that is difficult to granulate, while tartaric acid alone makes the granules easily agglomerate; the combination of the two produces better granule characteristics. Sodium bicarbonate was chosen as a base source because it is non-hygroscopic, more reactive than other forms of carbonate, relatively inexpensive, and can improve the taste of the resulting effervescent solution [15].

The combination ratio of the two extracts was kept at 1:1 in all formulas (F2, F3, F4) with the aim of observing the effect of increasing the total extract concentration on antioxidant activity, not to determine the most dominant extract. This approach is based on the consideration that red dragon fruit peel is rich in polyphenols and betacyanins while lime peel is rich in flavonoids and vitamin C, so that the 1:1 ratio is considered the ideal balance point to produce a synergistic effect without being dominated by one ingredient.

e. Physical Quality and Stability of Effervescent Granules

The results of the flow rate and angle of repose test on all formulas (Table 4) show values that meet the requirements for good flowability (≤40°), indicating that the granules have a fairly uniform particle shape and size so that they can flow freely due to gravity without experiencing particle clumping [15]. These good flow characteristics are important because they are directly related to the uniformity of the active ingredient content in each package and the ease of filling the granules into containers during larger-scale production processes.

The dissolution time of the four formulas ranges from 1.09 to 1.15 minutes, fulfilling the requirements for good effervescent solubility, which is 1-2 minutes [11]. This indicates that the reaction between the acid and base components takes place optimally when in contact with water so that carbon dioxide gas is formed properly and the granules dissolve quickly. The pH value of the four formulas (5.88-6.14) is also within the required neutral range (5-7) [16], so the preparation is safe for consumption because it does not risk causing stomach irritation (if too acidic) or an uncomfortable bitter taste (if too alkaline).

The moisture content of the granules in all formulas (1.42-2.40%) was well below the maximum limit of 4% [17]. A certain amount of moisture content is actually needed to form interparticle bonds so that the granules have good cohesiveness, but excessive moisture content can trigger particle aggregation and agglomeration so that the granules become difficult to flow. The low moisture content in this study also explains the good flow rate results in all four formulas.

The results of the hedonic test showed the highest level of panelist acceptance in Formula 3 (81.75%), followed by Formula 4 (80.5%), Formula 2 (76.25%), and Formula 1 (71.5%), supported by high preferences in color parameters (91%) and taste (80%) in Formula 3. This indicates that the addition of extract concentration to a certain limit has a positive effect on consumer preferences through the intensity of the pink color and the preferred sweet-sour taste, although it should be noted that the highest organoleptic preference (Formula 3) is not always in line with the highest antioxidant activity (Formula 2), so that the determination of the optimal formula needs to consider the balance between pharmacological efficacy and consumer acceptance.

Physical stability testing using the method of *cycling test* showed that all formulas were able to maintain color, odor, and taste consistently despite changing shape to clumpy granules. This clumping is related to the hygroscopic nature of the effervescent components, which are sensitive to temperature and humidity fluctuations during the test cycle, where the absorption of water vapor causes the granule particles to bond together and form clumps. This finding indicates the need for airtight packaging (e.g., aluminum foil or moisture-resistant) to maintain the stability of the granule shape during the product storage period.

f. Antioxidant Activity

Vitamin C was used as a positive control because it functions as a secondary antioxidant that effectively captures free radicals and prevents chain reactions, has high antioxidant activity, is easily obtained, and is more polar than other vitamins so it dissolves well in polar solvent-based test systems [23]. The IC50 value of vitamin C of 18.015 ppm confirms that the greater the concentration of vitamin C, the stronger its ability to inhibit DPPH free radicals, as indicated by the highest inhibition percentage (14.141%) at a concentration of 8 ppm [24].

A single extract of red dragon fruit peel (IC50 10.462 ppm) showed slightly stronger antioxidant activity than a single extract of lime peel (IC50 13.951 ppm), but both were still classified as very strong (IC50 <50 ppm). This difference is likely related to the length of maceration time and the total content of phenolic compounds in each ingredient, because the longer the maceration time, the more bioactive compounds are extracted so that the IC50 value obtained is smaller, which means the antioxidant activity is greater [25]. The concentration of the extract also affects the absorbance value of the test solution, where increasing the concentration of the extract causes a decrease in absorbance and a proportional increase in the percentage of DPPH radical scavenging [26].

The most interesting finding in this study is the non-linear pattern of IC50 values of effervescent granules with increasing extract concentration. Formula 2 (each extract concentration 1%) produced the lowest IC50 value (7,540 ppm), even lower than the single extract of red dragon fruit peel and lime peel as well as the positive control of vitamin C. This indicates a possible synergistic effect between polyphenol/betasianin compounds from red dragon fruit peel and flavonoid/vitamin C from lime peel in capturing DPPH free radicals through complementary electron and hydrogen atom donor mechanisms. However, further increase in extract concentration in Formula 3 (IC50 12,721 ppm) and Formula 4 (IC50 8,163 ppm) actually showed a tendency to increase the IC50 value compared to

Formula 2, which can be explained by several possible mechanisms, namely: (1) the occurrence of saturation of DPPH radicals with the available antioxidant concentration so that increasing concentration is no longer directly proportional to the increase in radical scavenging activity; (2) disruption of interactions between extract components at high concentrations which can change the solubility and reactivity of active compounds; and (3) the possibility of pro-oxidant effects at high concentrations, namely a condition where antioxidant compounds can actually be oxidized and produce new reactive species, thereby reducing the overall efficiency of the system in neutralizing free radicals.

Comparison with commercial products of herbal granules based on chrysanthemum flowers (IC50 21,271 ppm) [27] shows that all effervescent granule formulas combining red dragon fruit peel and lime peel extracts in this study have much stronger antioxidant activity, thus proving the added value and competitiveness of products resulting from the utilization of fruit peel waste compared to similar products already circulating in the market. Overall, these results prove that Formula 2 with a concentration of each extract of 1% (ratio 1:1) is the optimal point of the formulation that balances the efficiency of raw material use with the highest antioxidant efficacy, so it is recommended as the selected formula for further product development.

4. CONCLUSION

Based on the results of research on the formulation and antioxidant activity test of effervescent granules combined with red dragon fruit peel extract (*Hylocereus polyrhizus W.*) and lime peel (*Citrus aurantifolia S.*) with the DPPH method, several conclusions can be drawn as follows. First, the combination of red dragon fruit peel and lime peel extracts has been proven to be able to be formulated into effervescent granule preparations that meet all required physical quality standards. The four formulas (F1-F4) showed a flow rate of 3.45-8.50 g/s and an angle of repose of 22.25°-26.37° (requirement ≤40°), a dissolution time of 1.09-1.15 minutes (requirement 1-2 minutes), a pH of 5.88-6.14 (requirement 5-7), and a water content of 1.42-2.40% (requirement ≤4%), all of which are within the range of requirements for good effervescent granule preparations. These results are in line with the research objectives formulated in the Introduction, namely to prove that red dragon fruit peel and lime peel waste can be developed into practical pharmaceutical dosage forms without sacrificing the physical quality of the product.

Second, the antioxidant activity of the effervescent granule preparation of the combination of the two extracts is classified as very strong in all tested formulas, with IC50 values of 9.715 ppm (F1), 7.540 ppm (F2), 12.721 ppm (F3), and 8.163 ppm (F4), respectively, all of which are far below the threshold of 50 ppm for the very strong antioxidant category. These values are even lower than the IC50 of vitamin C as a positive control (18.015 ppm) and the commercial comparison product of chrysanthemum granules (21.271 ppm), thus proving that the developed preparation has a competitive advantage as a natural antioxidant functional food product.

Third, Formula 2, with a concentration of red dragon fruit peel and lime peel extracts of 1% each (ratio 1:1), was identified as the best formulation because it had the smallest IC50 value (7,540 ppm) among the four formulas tested, in accordance with the principle of DPPH analysis that the smaller the IC50 value, the higher the preparation's ability to ward off free radicals. The non-linear pattern of IC50 values with increasing extract concentration in Formula 3 and Formula 4 indicates an optimal saturation point in the combination formulation of the two extracts, so that increasing concentration is not always directly proportional to increasing antioxidant activity.

In general, this research succeeded in answering all the problem formulations and objectives set, while also opening up prospects for further development in the form of a comprehensive antioxidant activity test *in vivo* to confirm the pharmacokinetic profile and bioavailability of the preparation, the use of comparative analysis methods such as FRAP (*Ferric Reducing Antioxidant Power*) or ABTS to strengthen claims of antioxidant activity, as well as long-term stability and accelerated stability testing to determine shelf life (*shelf-life*) products precisely before being applied on a wider production scale as functional food products based on local Indonesian fruit peel waste.

5. ACKNOWLEDGEMENT

The author would like to express his gratitude to the Undergraduate Study Program of Pharmacy, Faculty of Health Sciences, Duta Bangsa University, Surakarta for the Natural Materials Laboratory facilities provided during the research, to the supervising lecturer for scientific direction and guidance, to UPF Yankestrad RSUP Dr. Sardjito for the plant determination services, to all panelists who participated in the hedonic test, and to all parties who have helped carry out this research until its completion.

6. BIBLIOGRAPHY

[1] Asrifaturofingah, E. Listiowati, F. U. Matsna, S. Z. Putriliana, and N. A. H. Ulya, "Analisis Aktivitas Senyawa Antioksidan Pada Berbagai Daun Tanaman Herbal dengan Metode DPPH," Jurnal Pharmascience, vol. 11, no. 1, pp. 98-114, 2024.

[2] S. Puspitasari, Y. B. Soemarie, and A. Fadillah, "Uji Aktivitas Antioksidan Dari Kulit Buah Naga Merah (Hylocereus Polyrhizus)," vol. 6, no. 4, pp. 1061-1072, 2025.

[3] K. R. Handayani, T. A. Putri, and Unaisah, "Pengaruh Konsentrasi Ekstrak Jeruk Nipis (Citrus aurantifolia) Terhadap Mutu Granul Dan Tablet Effervescent," vol. 16, no. 2, pp. 226-239, 2025.

[4] I. Hairunisa, R. Nurjunnah, and T. B. Julianti, "Formulasi dan Evaluasi Fisik Granul Effervescent Kombinasi Ekstrak Stenochlaena palustris dan Psidium guajava L. dengan Variasi Konsentrasi Asam sebagai Suplemen," vol. 11, no. 2, pp. 667-681, 2025.

[5] D. A. Winahyu, R. C. Purnama, and M. Y. Setiawati, "Uji Aktivitas Antioksidan Pada Ekstrak Kulit Buah Naga Merah (Hylocereus polyrhizus) Dengan Metode DPPH," vol. 4, no. 2, pp. 117-121, 2019.

[6] U. Mardiana, F. Sayyidina, and K. Novitriani, "Uji Aktivitas Antioksidan Ekstrak Kulit Buah Naga (Hylocereus Monacanthus)," vol. 8, no. 2, pp. 326-339, 2025.

[7] R. Niah and Helda, "Aktivitas Antioksidan Ekstrak Etanol Kulit Buah Naga Merah Daerah Pelaihari, Kalimantan Selatan Dengan Metode DPPH," vol. 3, no. 2, pp. 36-42, 2016.

[8] R. Novriyanti, N. E. K. Putri, and L. Rijai, "Skrining Fitokimia dan Uji Aktivitas Antioksidan Ekstrak Etanol Kulit Jeruk Nipis (Citrus aurantifolia) Menggunakan Metode DPPH," Media Pharmaceutica Conference, pp. 27-29, 2022.

[9] I. Khasanah, M. Ulfah, and Sumantri, "Uji Aktivitas Antioksidan Ekstrak Etanolik Kulit Buah Jeruk Nipis (Citrus aurantifolia) Dengan Metode DPPH," pp. 9-17, 2016.

[10] A. S. Yasir, A. M. Ulfa, and C. R. Raihannisa, "Perbandingan Aktivitas Antioksidan Ekstrak Daun Kelor (Moringa oleifera Lam) Dan Kulit Jeruk Nipis (Citrus aurantifolia)," vol. 7, no. 4, pp. 1016-1025, 2024.

[11] F. A. Toding, N. P. Dewi, T. Dermiati, and S. W. Wulandari, "Aktivitas Antioksidan Granul Effervescent Ekstrak Kulit Buah Naga Merah (Hylocereus polyrhizus W.) Menggunakan Metode DPPH," vol. 15, pp. 973-983, 2024.

[12] T. M. Yunitasari, "Formulasi dan Uji Aktivitas Antioksidan Granul Effervescent Ekstrak Daun Bayam Batik (Amaranthus bicolor) Dengan Metode DPPH," 2024.
[13] R. N. Ramdhini, "Standarisasi Mutu Simplisia Dan Ekstrak Etanol Bunga Telang (Clitoria ternatea L.)," vol. 13, no. 1, pp. 32-38, 2023.
[14] Badan Pengawas Obat dan Makanan Republik Indonesia (BPOM RI), Persyaratan Mutu Obat Tradisional. Jakarta: BPOM RI, 2014.
[15] F. N. Syaputri, S. Z. Saila, T. D. A. Tugon, A. P. R., and D. Lestari, "Formulasi dan Uji Karakteristik Fisik Sediaan Granul Effervescent Ekstrak Etanol Daun Sirih Merah (Piper crocatum) Sebagai Antidiabetes," vol. 4, no. 1, pp. 191-198, 2023.
[16] C. E. V. Sari, T. A. Listyani, and A. Fitriawati, "Formulasi Dan Uji Aktivitas Antioksidan Granul Effervescent Ekstrak Infusa Daun Leunca (Solanum nigrum L) Dengan Menggunakan Metode DPPH," vol. 5, pp. 13489-13503, 2024.
[17] S. Luliana, S. Amalia, and Isnindar, "Formulasi Serbuk Instan Ekstrak Pegagan (Centella asiatica) dan Jahe Merah (Zingiber officinale Roscoe var. Rubrum)," vol. 5, pp. 372-381, 2023.
[18] N. Qamariah, R. Handayani, and A. I. Mahendra, "Uji Hedonik dan Daya Simpan Sediaan Salep Ekstrak Etanol Umbi Hati Tanah," Jurnal Surya Medika, 2022.
[19] B. E. Wijaya and R. Hutabarat, "Formulasi Dan Uji Stabilitas Sediaan Granul Effervescent Ekstrak Daun Kelor (Moringa Oleifera Lam.)," vol. 1, pp. 528-542, 2024.
[20] M. Andry, S. U. Karo-Karo, I. P. Lubis, E. S. Lubis, M. A. Lubis, and H. R. Nasution, "Uji Aktivitas Antioksidan Kombucha Daun Alpukat (Persea americana Mill.) Berdasarkan Lama Fermentasi Dengan Metode ABTS," pp. 2609-2622, 2025.
[21] H. Widyowati, M. Ulfah, and Sumantri, "Uji Aktivitas Antioksidan Ekstrak Etanolik Herba Alfalfa (Medicago sativa L.) Dengan Metode DPPH," pp. 25-33, 2014.
[22] M. Oktavia, K. J. Pratama, and N. Luthfiyanti, "Uji Aktivitas Antioksidan Ekstrak Metanol dan Fraksi Kulit Buah Markisa Konyal (Passiflora Ligularis Juss) dengan Metode DPPH," vol. 3, no. 4, pp. 3116-3125, 2025.
[23] F. V. Damanis, D. S. Weweangkang, and I. Antasionasti, "Uji Aktivitas Antioksidan Ekstrak Etanol Ascidian Herdmania Momus Dengan Metode DPPH," vol. 9, pp. 464-469, 2020.
[24] S. A. Sangkala, M. R. Jura, and I. M. Tangkas, "Uji Aktivitas Antioksidan Ekstrak Buah Merah (Pandanus baccari L) Di Daerah Poso Sulawesi Tengah," vol. 3, pp. 198-205, 2014.
[25] R. O. Umboro, D. E. B. S, and N. K. W. Yanti, "Uji Efektivitas Antioksidan (IC50) Dan Toksisitas Akut (LD50) Fraksi Etanol Daun Nangka (Artocarpus Heterophyllus Lam.)," vol. 5, no. 6, 2020.
[26] M. Taswin and A. Oktarida, "Efektivitas Antioksidan Ekstrak Buah Naga Merah (Hylocereus polyrhizus) Dan Buah Naga Putih (Hylocereus undatus) Dengan Metode DPPH Secara Spektrofotometri UV-Vis," vol. 2, no. 2, 2020.
[27] K. M. Maheira and R. S. Firdausia, "Uji Aktivitas Antioksidan Ekstrak Etanol Bunga Krisan (Chrysanthemum morifolium Ramat) dengan Metode DPPH," vol. 9, no. 2, pp. 179-188, 2023.
[28] S. A. Pratiwi, N. Februyani, and A. Basith, "Skrining dan Uji Penggolongan Fitokimia dengan Metode KLT pada Ekstrak Etanol Kemangi (Ocimum basilicum L) dan Sereh Dapur (Cymbopogon citratus)," vol. 6, no. 2, pp. 140-147, 2023.