



Characteristics of Red Hard Candy with Addition of Roselle (*Hibiscus sabdariffa* L.) Flower Extracts

Airiza Sekardina¹, Supriyanto Supriyanto^{1,2}, Mojiono Mojiono^{1,2*} and Hadi Suprpto³

¹Department of Agroindustrial Technology, Faculty of Agriculture, Universitas Trunodjoyo Madura, Bangkalan 69162, Indonesia.

²Department of Food Technology, Faculty of Agriculture, Universitas Trunodjoyo Madura, Bangkalan 69162, Indonesia.

³Department of Agricultural Product Technology, Faculty of Agriculture, Universitas Mulawarman, Samarinda 75124, Indonesia.

*Corresponding author: mojiono@trunojoyo.ac.id

Received 26 March 2024
Revised 29 December 2025
Accepted 1 April 2026

Abstract

There is a growing interest in replacing synthetic dyes with natural colouring agents, primarily driven by increasing health concerns among consumers worldwide. This work aimed to reformulate hard candy products through incorporating different levels of roselle flower extracts (6-15 g) as an alternative colouring agent. The samples were also enriched with Javanese long pepper extract as a source of functional components and xylitol as an alternative sweetener. In this work, the properties of hard candy, including pH, solubility time, colour variation (expressed as Red, Green, and Blue – RGB), DPPH radical scavenging (% inhibition), and sensory acceptability, were evaluated. As a result, while pH, colour, and free radical inhibition were significantly altered, the treatments given did not affect solubility time. The pH level decreased consistently as the amount of roselle flower extract increased. Conversely, the RGB values and percentage inhibition increased with greater incorporation of roselle flower extracts into the formulation. In the case of colour, a higher proportion of the extract led to higher RGB values in hard candy, corresponding to a greater level of brightness achieved by F4. Meanwhile, F2 demonstrated the highest red intensity. Furthermore, the treatments resulted in significant effects on all sensory attributes, except aroma. F1 reached the highest sensory score for taste, texture, and overall attributes, while F2 reached the highest for colour. The work results confirm the further use of roselle flower in the formulation of red hard candy.

Keywords: Formulation, Hard candy, Javanese long pepper, Natural colourants, Roselle flower extract

1. Introduction

Numerous studies have actively explored the application of natural ingredients in food products [1], which has been encouraged by growing global interest in a healthier lifestyle. Consumer groups are increasingly concerned about the safety of synthetic colourants. The colourants are preferred by the industry due to their desirable properties, but natural alternatives are gaining more appeal to consumers [2]. Additionally, many naturally derived colourants may offer health benefits [3]. The use of food colours in various types of commodities is intended to enhance their visual appeal or compensate for natural colour variations [4]. Notwithstanding the fact that natural dyes have several drawbacks, such as lower stability and undesired colour appearances [3], the replacement of artificial colour with natural ones can be promising for the future. Tartrazine, sunset yellow, and brilliant blue are synthetic pigments, and these chemicals have the advantages of bright colour, high potency, good stability, and low cost. They are widely used in the colouring of candy, cakes, and drinks in the food industry. However, excessive pigment is toxic and can lead to cancer or death [5], which has sparked the search for safer colouring agents.

Concerning alternative colourants, *Hibiscus sabdariffa* L. (Roselle) may be a potential food colourant. The

plant belongs to the Malvaceae family and has long been recognised as a medicinal plant cultivated in various parts of the world, including Africa, Southeast Asia, and Central America. It has various names, such as Jamaica flowers, Sorrel, and Karkdah (in Egypt) [6]. In Thailand, roselle is a popular and widely cultivated plant, locally known as Krachiap Daeng. The plant bears red, edible calyxes, which are primarily used to make red-coloured products such as jam, jelly, and juice [7]. A jelly candy was successfully made, and roselle calyx was incorporated into the formulation for colourant [8]. Roselle also has considerable industrial, pharmaceutical, and economic value in Egypt and many other countries around the world, mainly due to its pleasant sepals [9]. A work [6] reports that roselle has been widely used as a flavouring for sauces, jellies, marmalades and soft drinks or to use as a colourant for foods, which roselle appears to be a good and promising source of water-soluble natural red colourants.

In this regard, the present work develops a new recipe of red hard candy products by adding roselle flower extracts as a colouring agent. To improve functional properties, the sugars are partially replaced by xylitol, and Javanese long pepper (*Piper retrofractum* Vahl.) extracts is also added to the formulation. Chemically, xylitol is obtained from lignocellulosic biomass, which is a cheap and abundant raw material throughout the planet, and the demand for xylitol worldwide has increased due to the low caloric content and anticaries action of this polyol [10]. A study [1] developed sucrose-free hard candies added with three different polyols: isomalt, maltitol syrup, and xylitol. In this case, despite giving an undesirable effect on moisture content and hardness, resulting in decreased texture acceptability, xylitol improved color and clarity of the candies. Food products which have less sugar in their composition have become a marketing trend in current years, as a response to the rise of health concern.

Javanese long pepper extract has been extensively researched as a significant local commodity of Madura, an island in Indonesia. It possesses potential nutritional and phytochemical values that support its use for pharmaceutical purposes [11,12]. For example, the fruit contained calcium, copper, iron, magnesium, phosphorus, potassium, sodium and zinc in different levels, and other chemicals such as quinone, sterol, glycosides and alkaloid were detected in both n-hexane and ethyl acetate extracts, as well as tannin presented in ethyl acetate and methanol extracts. Considering its potential uses for food ingredients, our previous work investigated the supplementation of Javanese long pepper extract on hard candies [13], and showed that the functional properties of the hard candies were improved by the addition of the extracts. This work aimed to characterise hard candies enriched with roselle flower extracts with regard to their colours, pH, solubility time, percentage inhibition, and sensory analysis.

2. Materials and Methods

2.1 Preparation of extracts and hard candy samples

Dried Javanese long pepper was supplied from a local farmer in Sumenep, the central area of Javanese long pepper farming in Madura Island, Indonesia. The dried fruits were crushed into powder using an electric grinder. The powder was soaked in distilled water at a ratio of 1:10 (w/w), and infused for 10 min at ± 100 °C under constant stirring. Following the heating process, the temperature was cooled to room temperature, and the mixture was filtered using filter paper. The filtrate was evaporated using a rotary evaporator (B-One) for 15 min at 45 °C, resulting in the extract of Javanese long pepper. For the extraction of roselle flowers, the petals were trimmed and washed, while the seeds were discarded. Roselle petals were boiled in water (1:2, w/w) for 10 min to produce roselle petal extracts. The extracts were stored in a refrigerator for further use.

The preparation of hard candy samples followed a method previously described in a former work [13]. In this case, the roselle extract was added to the formulation as a natural colourant. All ingredients, as specified in Table 1, were weighed. Water, xylitol, and glucose were mixed thoroughly in a beaker glass and heated at 140 °C for 15 min. At this point, both extracts (Javanese long pepper and roselle) were added and mixed. The heating was terminated, and the final candy paste was immediately poured into silicon moulds. Hard candies were removed from the moulds and packed in aluminium bags. They were stored in a refrigerator (± 4 °C) for further analysis.

Table 1 Formulation of hard candies with roselle extracts

Composition	F1	F2	F3	F4
Xylitol (g)	30	30	30	30
Glucose (g)	70	70	70	70
Water (g)	10	10	10	10
Javanese long extracts (g)	10	10	10	10
Roselle flower extracts (g)	6	9	12	15
Total (g)	126	129	132	135

2.2 Analyses

All hard candies were tested for physical and chemical attributes, i.e., pH, colour, solubility time, and percentage inhibition by DPPH assays. All tests were performed in triplicate. The pH level of hard candies was determined using a pH meter (Senz pH tester). RGB colour measurement complied with a procedure of [13] using ImageJ software, described in the RGB (Red-Green-Blue) colour system. Briefly, hard candy samples were photographed using a DSLR camera (Canon 1300D) set in Food Mode at a constant distance of approximately 30 cm above the sample. The photographing was conducted in a specially designed box, enabling the removal of unwanted external light. The image files were analysed in the ImageJ software. RGB color profile between samples was compared.

Regarding the solubility time of hard candy (expressed in minutes), the procedure followed a former method [13]. Sample (5 g) was dissolved in 10 mL of distilled water in a beaker glass and heated up to 30 ± 2 °C and constantly stirred at 20 rpm in a hot plate (Thermo Scientific ELED SP142020-33Q). The time required to completely dissolve the candy was observed.

The free radicals inhibition percentage of the samples was determined using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay. Briefly, a series of DPPH reagent solutions was prepared (20 - 100 ppm). Meanwhile, hard candies were dissolved in distilled water, and 2 mL of each sample was reacted with 1 mL of DPPH, and incubated for 20 min in a dark room. Blank solution was also prepared. All samples were checked for absorbance at 517 nm using a Spectrophotometer UV-Vis (Genesys 10S). The percentage inhibition was calculated as follows:

$$\% \text{ Antioxidant} = \frac{\text{Abs for blank} - \text{Abs for sample}}{\text{Abs for blank}} \times 100\%$$

A sensory test was carried out according to a former work [13]. The test was used to determine consumer acceptability regarding the characteristics of hard candies covering taste, aroma, colour, texture and overall. The panellists (15 semi-trained panellists) were asked to taste the samples and rate them based on a 5-point scale as follows: extremely like (5), very like (4), neutral (3), dislike (2), extremely dislike (1).

2.3 Statistical Analysis

Data were statistically analysed using One-Way ANOVA (Analysis of Variance) in SPSS 25 software, with a 95% confidence level. Tukey test was run to verify the difference between means.

3. Results and Discussion

3.1. pH, Solubility Time, and DPPH Assay

Hard candies were characterised for pH, solubility time, colour, and free radical inhibition percentage (Table 2). The pH level ranged from 2.8 to 3.4, and it was evident that the concentration of roselle flower extracts had a significant effect on pH ($p < 0.05$). The pH level was also compared with three commercial products. As a result, these commercial hard candies had higher level of pH between 4.05 and 4.20 (data not shown). This means that the hard candies studied are more sour than commercial products. The acidity may result from organic acids of the roselle calyx. The calyx is reported to contain organic acids such as malic, tartaric, citric, glycoside, and hepiscin chloride [14], which declined the pH level of samples. In another study [8], the pH level in roselle calyx jelly candy reached 3.1–3.4, while the control had a pH level of 4.7. This obviously suggests that roselle flower decreases the pH of the candies.

Table 2 Values of pH, solubility time, colour, and antioxidant of hard candies

Samples	pH	Solubility time (min)	RGB colour	Percentage of inhibition (%)
F1 (6 g)	3.4 ± 0.07^c	12.27 ± 0.05	24.88 ± 0.47^a	22.5 ± 2.94^a
F2 (9 g)	3.0 ± 0.07^b	13.45 ± 0.13	43.96 ± 0.22^b	59.5 ± 0.70^b
F3 (12 g)	2.8 ± 0.00^a	13.92 ± 0.47	52.58 ± 0.95^c	73.5 ± 0.70^c
F4 (15 g)	2.8 ± 0.07^a	15.53 ± 1.50	54.53 ± 0.17^d	72.5 ± 2.12^c

Notes: values are expressed in mean $\pm$ standard deviation (n=3). Different superscripts following the means in similar column show significant differences at $p < 0.05$.

Regarding solubility time, this attribute is essential since it may estimate the melting time of the hard candy. Hence, this mouth-like condition, constant stirring at low speed and 30 °C, roughly approximates what actually occurs in the mouth. There was an increase of solubility time as more roselle flower extract was added. However, the treatment did not affect solubility time significantly ($p > 0.05$). In F1 sample, it reached about 12.27 min, and increased consistently up to 15.53 min for F4 (Table 2). We also compared this parameter with three commercial

hard candies (similar weight of ± 2 g per sample), reaching 19.58 – 27.23 min (data not shown).

The inhibition of free radicals varied greatly between samples ($p < 0.05$). The lowest percentage was obtained in F1 (22.5%), corresponding to the lowest level of roselle flower extract. Afterwards, it increased up to 59.5% in F2. The highest antioxidant levels were achieved in F3 (73.5%) and F4 (72.5%), although the differences were not statistically significant. Regarding antioxidant effects, anthocyanin was identified as the primary source of antioxidant capacity in roselle extracts. The inhibition also came from the brown pigment of the roselle, despite showing lower effects [15]. In this work, the results of percentage inhibition were higher than those reported by a former study. A previous investigation [16] formulated hard candy with antiviral herbal extracts and Citrus limon peel essential oils, and the DPPH free radical scavenging activity was measured, yielding good inhibition (26.4%). Again, this demonstrates that roselle flower extract enhances the antioxidative effects of hard candy, thereby cultivating its prospects for the development of hard candy products with functional properties. The bioactivities often change as components may degrade during processing, highlighting the need for fortification to compensate for the loss [17].

3.2. Sample Colours

Colour variation of the hard candy is approached by the RGB colour system. In the RGB colour model, colours are represented through a mix of red, green, and blue values. Each component in the RGB triplet can range from 0 to a specified maximum of 255. When all three components—R, G, and B—are set to 0, the resulting colour will be black. On the other hand, when R, G, and B are all at their maximum value of 255, the resulting colour is white [18]. The results showed that the RGB values increased significantly with the addition of roselle flower extract ($p < 0.05$), as specified in Table 2. The F1 sample had an RGB value of 24.88, and the colour was almost doubled in the F2 sample with 43.96. A dramatic surge in RGB value occurred in F3 (52.58) and in F4 (54.53). Based on RGB values, roselle flower extracts produced greater colour intensity of the samples tested, which corresponds to brightness. Figure 1 displays appearances of hard candy samples. Compared with another result [13], RGB values ranged between 63.92 and 70.82, and the control sample showed the highest RGB value, although it was not significantly different. Another work reported the RGB score for hard candy samples reached 60.821 [19].

Looking more closely at the colour of samples, since the red colour dominates the sample appearance, further checks on redness intensity are carried out. Overall, a clear difference in the intensity of redness was observed between samples (Figure 2). Samples F2, F3, and F4 showed more intense red colour, reaching 92.9, 82.4, and 84.1, respectively. Meanwhile, the red intensity for sample F1 was only 30.9, corresponding to the lowest redness. This finding illuminates new insight that red intensity of hard candy would be stronger with the rise of roselle flower extract concentration in the formulation. The hibiscus is dark red in colour in the acid medium due to the presence of betacyanin, and its dark red pigments are used in food and as hair dye, besides numerous medicinal uses [14].

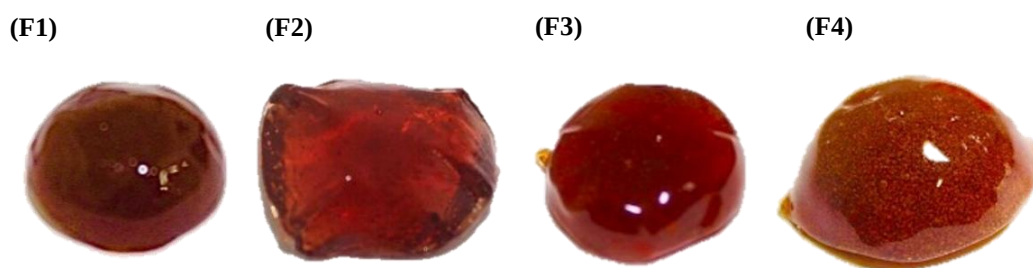


Figure 1 Physical appearances of hard candies prepared from different levels of roselle flower extract

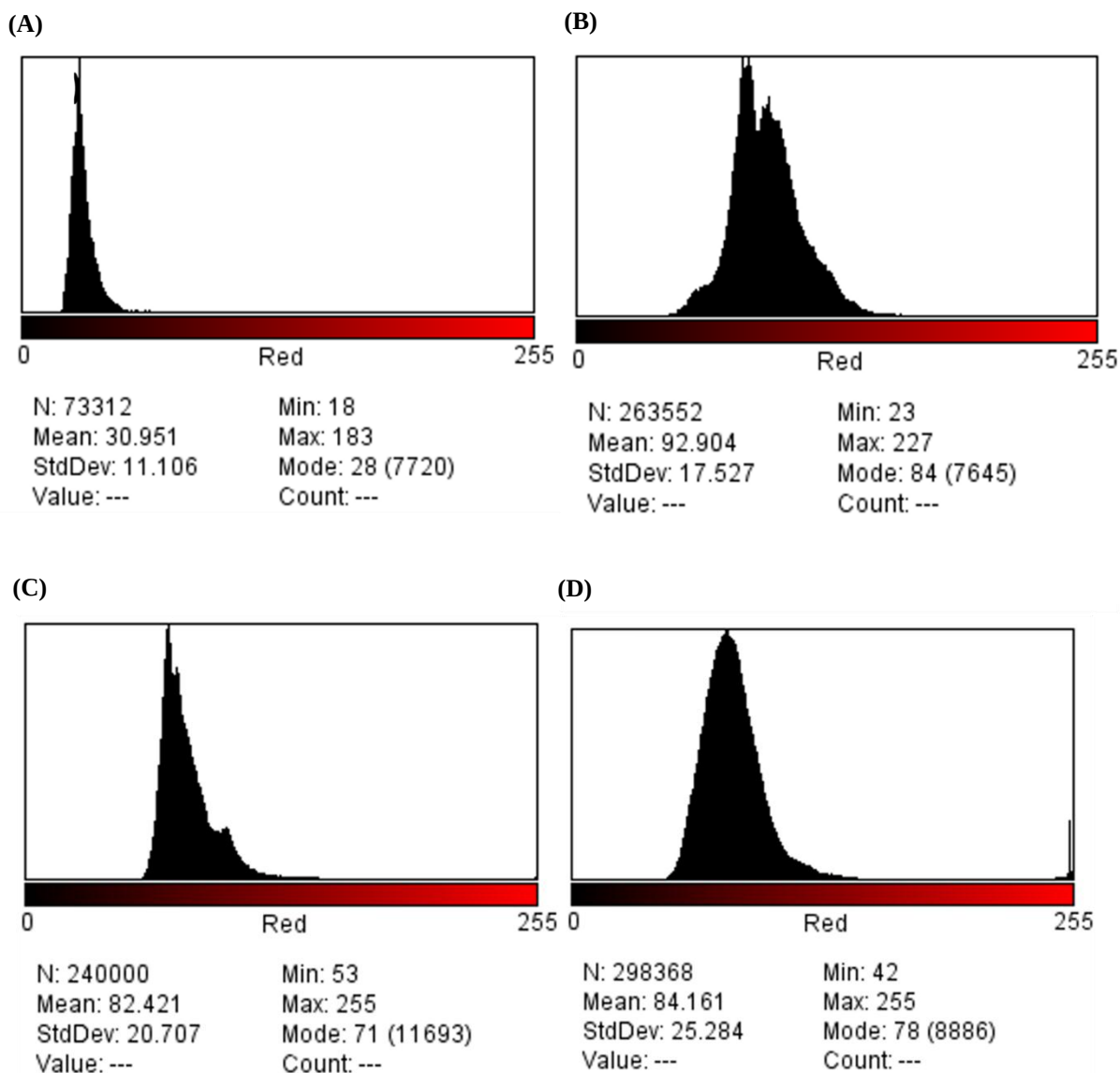


Figure 2 Differences in red intensity of F1 (A), F2 (B), F3 (C), and F4 (D) samples.

3.3. Sensory Profiles

Table 3 shows sensory acceptability of hard candy with regard to taste, aroma, texture, color, and overall. A higher score indicates a stronger preference among panellists. In general, roselle flower extract affects attribute acceptability, except for aroma. In case of taste, F1 had the highest score (3.73), although it did not differ with F2 (3.60). Panellists had a lower preference for the F3 sample, with only 3.53, but it was significantly higher than the F4 sample, with 2.60. This test shows that panellists' preference tended to decline as a high proportion of roselle flower extract in the candy formulation. Moving to aroma, despite not being significant between samples tested, it can be explained that the acceptability of panellists is more than 2.5, but not outweighing 3.0 (neutral). This suggests that further attempts should consider the development of aroma.

Regarding the texture of candy, there was a trend that panellists preferred candy with a lower content of roselle flower extract. The highest score was 3.80, achieved by the F1 sample, and this significantly differed from other samples. On the other hand, the lowest preference was attributed to F2 and F3, with a score of no more than 2.5. The most likely problem with hard candy texture is stickiness. As this product contains xylitol, the moisture content is higher. This relates to the high hygroscopicity of xylitol, as it has a high number of active hydroxyl groups (-OH) that bond with water molecules, compared to other sweeteners. Hence, xylitol-containing candies are more hygroscopic and have a relatively high moisture content, which can generate a stickiness problem [1].

In the case of colour, F2 achieved the highest score with 4.13, which was significantly higher than the scores of the other samples. Intriguingly, F4, containing the highest content of roselle flower extract, had the lowest

acceptability, reaching only 3.07. The preference for F3 and F1 was higher than F4, reaching 3.67 and 3.33, respectively. In terms of overall liking, it was found that panellists were most pleased by the F1 sample (3.87), a hard candy with the lowest content of roselle flower extract. In contrast, F4 contained the highest level of roselle flower extract; however, it achieved an overall score of 2.67, which was the lowest among the samples studied.

Overall, this work supports the current trend in using plant-derived colourants in foods, including hard candy. As also argued by Dhawan *et al.* [20], adding herbs and spices to the product improves acceptability, adds value, and delivers the antioxidant and antimicrobial potential to consumers. For further work, the stability of roselle flower extracts at different pH levels needs to be investigated. Since the colour might change during storage, its stability and microbiological safety should be addressed in future works. Additionally, the types of sugars used in hard candy are crucial, as they significantly impact the shelf life of the products. Previously, a study [21] investigated the optimal formulation of three common sweeteners in hard candy, finding that optimal conditions could extend shelf life by up to 7 months beyond the industry-standard expiration date. In this work, the stability of the samples was not assessed, and further work could involve estimating potential colour changes during storage.

Table 3 Values of pH, solubility time, colour, and antioxidant of hard candies

Samples	Taste	Aroma	Texture	Colour	Overall
F1	3.73±1.09 ^{cd}	2.87±0.83 ^a	3.80±1.09 ^c	3.33±0.72 ^b	3.87±0.83 ^c
F2	3.60±0.97 ^{bc}	2.93±0.59 ^a	2.47±0.97 ^{ab}	4.13±0.63 ^d	3.33±0.89 ^b
F3	3.53±1.06 ^b	2.67±0.72 ^a	2.20±1.06 ^a	3.67±0.72 ^c	3.47±0.63 ^b
F4	2.60±0.82 ^a	2.80±0.56 ^a	3.20±0.82 ^b	3.07±0.96 ^a	2.67±0.72 ^a

Notes: values are expressed in mean ± standard deviation (n=3). Different superscripts following the means in similar column show significant difference at $p < 0.05$.

4. Conclusion

To summarise, the treatment showed significant effects on pH, colour, and inhibition of free radicals, but did not affect solubility time. The pH level declined continuously with the increased content of roselle flower extract. A reverse trend occurred in RGB values and percentage inhibition; both values were higher when more roselle was incorporated into the formulation. In the case of colour, a higher proportion of roselle flower extract increased RGB values, and F4 sample showed the highest score which is attributed to the brightest appearance, while F2 showed the highest red intensity. Additionally, the treatment had a significant impact on all sensory attributes, except for aroma. F1 reached the highest sensory score for taste, texture, and overall attributes, while F2 reached the highest for colour. This work signifies the further use of roselle flower in formulating hard candies, focusing on utilising natural colourants instead of synthetic ones. However, future works should be envisaged, including colour evaluation using more advanced methods as well as stability and microbiological safety tests during storage.

5. Acknowledgements

The authors acknowledge the Institute for Research and Community Service in Universitas Trunodjoyo Madura for funding this work through a National Collaboration Research scheme (Grant Number: 5899/UN46.4.1/PT.01.03/2023).

6. Conflict of Interests

The authors have declared that no conflict of interest exists

7. Author Contributions

Supriyanto, S.: Conceptualisation, Methodology, Investigation, Funding acquisition, Project administration, Supervision; Sekardina, A.: Investigation, Formal analysis; Mojiono, M.: Investigation, Data curation, Writing – original draft, Writing – review & editing, Software, Visualisation; Suprpto, H.: Writing – review & editing, Resources, Project administration.

8. References

- [1] Jeon Y, Oh J, Cho MS. Formulation optimization of sucrose-free hard candy fortified with cudrania tricuspidata extract. *Foods*. 2021;10(10):1–17.
- [2] Novais C, Molina AK, Abreu RMV, Santo-Buelga C, Ferreira ICFR, Pereira C, et al. Natural Food Colorants and Preservatives: A Review, a Demand, and a Challenge. *J Agric Food Chem*.

- 2022;70(9):2789–2805.
- [3] Wrolstad RE, Culver CA. Alternatives to those artificial FD&C food colorants. *Annu Rev Food Sci Technol.* 2012;3(1):59–77.
 - [4] Opladowska-Stachowiak M, Elliott CT. Food colors: Existing and emerging food safety concerns. *Crit Rev Food Sci Nutr.* 2017;57(3):524–548.
 - [5] He SH, Jiang H. Qualitative and quantitative analysis of some co-existing colorants in some hard candies. *J Food Compost Anal.* 2022;109:104475.
 - [6] Shruthi VH, Ramachandra CT, Nidoni U, Hiregoudar S, Naik N, Kurubar AR. Roselle (*Hibiscus sabdariffa* L.) as a source of natural colour: A review. *Plant Arch.* 2016;16(2):515–522.
 - [7] Chumsri P, Sirichote A, Itharat A. Studies on the optimum conditions for the extraction and concentration of roselle (*Hibiscus sabdariffa* Linn.) extract. *Songklanakarin J Sci Technol.* 2008;30:133–139.
 - [8] Halim Y, Evelyn C, Rosa D, Ramli S. Development of Roselle (*Hibiscus sabdariffa* L.) Calyx Jelly Candy. *Caraka Tani: J Sustain Agric.* 2022;37(2):357–372.
 - [9] Hussein RM, Shahein YE, El AE, Awad HM. Biochemical and molecular characterization of three coloured types of Roselle (*Hibiscus sabdariffa* L.). *J Am Sci.* 2010;6(11):726–733.
 - [10] Delgado Arcaño Y, Valmaña García OD, Mandelli D, Carvalho WA, Magalhães Pontes LA. Xylitol: A review on the progress and challenges of its production by chemical route. *Catal Today.* 2020;344:2–14.
 - [11] Jadid N, Arraniry B, Hidayati D, Purwani K, Wikanta W, Hartanti S, et al. Proximate composition, nutritional values and phytochemical screening of *Piper retrofractum* vahl. fruits. *Asian Pac J Trop Biomed.* 2018;7(1):37–43.
 - [12] Supriyanto S, Mojiono M. Inhibition of main protease enzyme (Mpro) by active compounds in cabya (*Piper retrofractum* Vahl.) for covid-19 treatment via in silico experiment. *IOP Conf Ser Earth Environ Sci.* 2022;1059(1).
 - [13] Supriyanto S, Mojiono M, Ambarwati Y. Supplementation of Javanese Long Pepper Extracts into Sucrose-Free Hard Candy for Improving Antibacterial Activity against *Streptococcus mutans*. *IOP Conf Ser Earth Environ Sci.* 2023;1182(1):012059.
 - [14] Mariod AA, Tahir HE, Mahunu GK. Composition of *Hibiscus sabdariffa* calyx, pigments, vitamins. In: Mariod AA, Tahir HE, Mahunu GK, editors. *Roselle (Hibiscus sabdariffa) Chemistry, Production, Products, and Utilization.* Academic Press; 2021. p. 69–75.
 - [15] Tsai PJ, McIntosh J, Pearce P, Camden B, Jordan BR. Anthocyanin and antioxidant capacity in Roselle (*Hibiscus Sabdariffa* L.) extract. *Food Res Int.* 2002;35(4):351–356.
 - [16] Souiy Z, Amri Z, Sharif H, Souiy A, Cheraief I, Hamden K, et al. The Use of D-Optimal Mixture Design in Optimizing Formulation of a Nutraceutical Hard Candy. Spigno G, editor. *Int J Food Sci.* 2023;2023:7510452.
 - [17] Samanta S, Sarkar T, Chakraborty R, Rebezov M, Shariati MA, Thiruvengadam M, et al. Dark chocolate: An overview of its biological activity, processing, and fortification approaches. *Curr Res Food Sci.* 2022;5:1916–1943.
 - [18] Minz PS, Saini CS. RGB camera-based image technique for color measurement of flavored milk. *Measurement: Food.* 2021;4.
 - [19] Supriyanto S, Mojiono M, Maflahah I. Optimisation of Sucrose-Free Hard Candy Enriched with *Piper retrofractum* Vahl Extracts Using Response Surface Methodology (RSM). *Trop J Nat Prod Res.* 2025;9(11):5565–5570.
 - [20] Dhawan K, Rasane P, Singh J, Kaur S, Kaur D, Avinashe H, et al. Effect of Spice Incorporation on Sensory and Physico-chemical Properties of Matcha-Based Hard Candy. *ACS Omega.* 2023;8(32):29247–29252.
 - [21] Spanemberg FEM, Korzenowski AL, Sellitto MA. Effects of sugar composition on shelf life of hard candy: Optimization study using D-optimal mixture design of experiments. *J Food Process Eng.* 2019;42(6):1–10.