Biointerface Research in Applied Chemistry
Open-Access Journal (ISSN: 2069-5837)

Article
Volume 16, Issue 1, 2026, 37
https://doi.org/10.33263/BRIAC161.037

Physicochemical Properties and Preference Level of Soft Candy with the Addition of Pressurized Blanched Turmeric (*Curcuma domestica* Val.) Extract

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Received: 16.06.2025; Accepted: 1.11.2025; Published: 15.02.2026

Abstract: Consumption of functional foods is increasing among the public, along with awareness of the benefits of bioactive compounds for health. Soft candy enriched with turmeric extract has strong potential as a functional food, given its curcumin content. This study aimed to analyze the effects of adding turmeric extract and varying pressurized blanching times on the physicochemical properties and preference levels of soft candy. The production of soft candy, which included turmeric, comprised the following steps: extraction, filtration, mixing with candy ingredients, heating, molding, cooling, cutting, drying, and subsequent chemical analysis of the finished candies. A randomized complete block design was employed with two factors: turmeric extract levels (5, 10, and 15%) and pressurized blanching time in distilled water and 0.05% citric acid media (0, 2.5, 5, and 7.5 minutes). The results showed that candies containing 15% turmeric extract, which was blanched for 2.5 minutes in distilled water and citric acid media, achieved the highest preference scores, 4.48 based on a 1–5 hedonic scale. Those blanched for 2.5 minutes in distilled water exhibited an antioxidant activity of 17.75% RSA and total phenolic of 5.06 mg GAE/g. In contrast, candies blanched in citric acid media showed 13.29% RSA antioxidant activity and a total phenolic content of 2.96 mg GAE/g.

Keywords: antioxidant activity; phenolic; turmeric; pressurized blanching; soft candy.

1. Introduction

Technological advancements have increased public awareness of the importance of bodily health, driving a preference for functional foods containing various bioactive compounds. Functional foods, as defined by [1], are foods that provide health benefits beyond their intrinsic nutritional value. This increased awareness contributes to a rising demand for food products that are not only nutritious but also have the potential to prevent degenerative diseases such as diabetes, hypertension, and cancer. Innovation in developing functional foods has become a primary focus in food science and public health. Nevertheless, the diversification of functional

food products remains a challenge that needs to be addressed to optimize health benefits for all segments of society [2].

Among various bioactive compounds used in functional foods, plant-derived polyphenols and curcuminoids have gained increasing attention due to their strong antioxidant and anti-inflammatory effects. Turmeric (*Curcuma domestica* Val.), rich in curcumin, represents one of the most promising natural sources of these compounds, making it highly relevant in the functional food industry.

Indonesia possesses a wealth of spices with the potential to serve as sources of antioxidants, known to have beneficial physiological effects on the body. Turmeric, a plant from the *Zingiberaceae* family, is one such Indonesian spice that is a source of antioxidants and has the potential to be a key ingredient in functional foods. The primary bioactive component in turmeric is curcumin, which exhibits anti-inflammatory properties and acts as an antioxidant [3]. The community's use of turmeric remains limited to cooking spices and traditional medicine. Therefore, it is necessary to optimize the development of turmeric utilization in functional food products, such as soft candy.

The use of turmeric extract at various concentrations in the production of soft candy is important for investigating the product's functional effectiveness and sensory acceptance. It is expected that appropriate variations in turmeric extract concentration can provide health benefits through the curcumin content while maintaining consumer acceptance of the candy's taste, color, and texture. Candy, a generally sweet snack, comes in various forms, including hard and soft varieties. Soft candy characteristics include a transparent appearance, a soft texture that is easy to cut yet firm enough to hold its shape, non-stickiness, and a smooth, fine surface without cracking. Gelatin, carrageenan, and agar are among the ingredients that contribute to the texture and chewiness of soft candy [4].

Previous research has shown that adding Javanese turmeric powder to soft candy at certain concentrations can increase consumer acceptance of taste, flavor, and warming sensation [5]. Given turmeric's potential as a rich source of antioxidants, research on the use of turmeric extract at various concentrations in candy production is relevant to explore. Therefore, this study needs to examine the optimal concentration of turmeric extract to produce candy with optimal functional benefits that are still favored by consumers.

Turmeric is renowned for its antioxidant properties, primarily due to its rich bioactive compound profile, which modulates signaling pathways involved in oxidative stress [6]. However, its use in food products faces challenges such as a bitter taste, pungent flavor, and intense color that can decrease consumer acceptance. In addition, the presence of oxidative enzymes and volatile compounds in turmeric can degrade bioactive components, such as curcumin, during processing and storage. One solution to address these problems is through pretreatment blanching, such as pressurized blanching.

Blanching aims to inactivate enzymes that can alter the color, texture, and taste of food ingredients. However, a blanching duration that is too short is ineffective at inactivating enzymes, while one that is too long can damage bioactive compounds such as curcumin. Therefore, determining the optimal blanching time is crucial to maintaining the sensory quality and functional content of the ingredients. The addition of citric acid during blanching is also important; it has been shown to retain color better than conventional methods, with lower processing temperatures leading to less color degradation, which can help stabilize the natural color of turmeric [7], prevent Maillard reactions, and increase the retention of active compounds during the thermal process [8].

Research by [9] has shown that blanching spices, such as white turmeric, can increase antioxidant activity compared to unblanched spices. Similarly, research by [10] found that cookies made from blanched turmeric have higher antioxidant activity and provide health benefits. Based on this background, this study aims to examine variations in the addition of turmeric extract and pressurized blanching time with Aquadest and 0.05% citric acid media in the production of soft candy. This study analyzed the physicochemical and sensory properties of the resulting turmeric soft candy to produce a product rich in antioxidants and favored by panelists. In addition, this research is expected to support the development of candy as a functional food with high economic value.

2. Materials and Methods

2.1. Material.

The primary material used in this research was 8 to 10-month-old turmeric rhizomes, obtained from CV Windra Mekar, Sedayu, Bantul, Indonesia. Additional materials included uncolored plain agar (Swallow, Indonesia), plain jelly (Nutrijell, Indonesia), granulated sugar (Gulaku, Indonesia), citric acid, and water. Chemical reagents used for analyses were ethanol (Merck), *2,2-diphenyl-1-picrylhydrazyl* (DPPH) solution (Sigma Aldrich), Aquadest, Nelson A reagent, Nelson B reagent, arsenomolybdate, sodium carbonate (Na_2CO_3) (Sigma Aldrich), Folin-Ciocalteu reagent (Sigma Aldrich), and Butylated Hydroxytoluene (BHT) (Sigma Aldrich).

The equipment employed for candy production comprised an autoclave, a digital scale (Camry), aluminum trays, a gas stove (Rinnai), a cabinet dryer, an impulse sealer, cheesecloth, and 100 mL graduated cylinders. Analytical equipment included a sartorius balance, a colorimeter, Whatman filter paper number 42, 50 mL beakers (Iwaki), funnels (Iwaki), 50 mL volumetric flasks (Iwaki), stirring rods, droppers, spatulas, weighing bottles (Pyrex), a vortex mixer, a texture analyzer, a desiccator, Erlenmeyer flasks (Iwaki), an oven, crucibles, and a spectrophotometer (Shimadzu UV mini).

2.2. Preparation of turmeric extract.

The initial stage in the production of soft candy involved the preparation of turmeric extract. This process was based on the method by [11], with certain modifications, using distilled water and citric acid media. The sorted turmeric rhizomes were peeled and washed with clean water. Subsequently, the turmeric underwent pressurized blanching in Aquadest and 0.05% citric acid solution at 120°C under 2 atm pressure for durations of 0, 2.5, 5, and 7.5 minutes. The blanched turmeric was then crushed and mixed with water at a ratio of 1:1 (water: turmeric). The resulting mixture was filtered through a filter cloth to obtain the turmeric extract. To provide a clearer overview of the experimental design, the factorial treatment combination (3 turmeric extract concentrations × 4 blanching durations × 2 blanching media) is summarized in Table 1.

Table 1. Factorial design of turmeric soft candy formulation.

Factor	Level	Description
Turmeric extract concentration	3 levels	5%, 10%, 15%
Blanching duration	4 levels	0, 2.5, 5, 7.5 minutes
Blanching media	2 levels	Aquadest and 0.05% citric acid
Total treatment combination	3x4x2=24	-

2.3. Soft candy processing.

The soft candy was prepared by weighing and mixing 194 g of granulated sugar, 7 g of agar, and 5 g of jelly powder, followed by dissolving the mixture in 293.5 mL of water. The solution was heated and stirred until boiling, and then 0.5 g of citric acid was added. Subsequently, the agar mixture was supplemented with turmeric extract at concentrations of 5, 10, and 15% per 500 g of the base mixture. The resulting mixture was molded in aluminum trays measuring 22×3 cm and cooled until it solidified. The solidified candy was then sliced into 2×2 cm squares and dried in a cabinet dryer at 50-55°C for 70 hours, to ensure gradual moisture reduction and to obtain a stable chewy texture with a moisture content below 15%, preventing stickiness and microbial growth during storage and yielding the final turmeric extract soft candy product. The research design employed was a factorial Randomized Block Design (RBD) with two factors: variations in turmeric extract concentration (5, 10, and 15%) and blanching time (0, 2.5, 5, and 7.5 minutes).

2.4. Physical properties analysis.

2.4.1. Color analysis.

The color of *Curcuma domestica* Val. soft candy was determined using the Colorimeter (3NH, Chinese). The parameters observed were L* (lightness), a* (redness/ greenness), and b* (yellowness/blueness).

2.4.2. Texture profile analysis.

Texture analysis of the soft candy samples was performed using a Brookfield CT3 texture analyzer. The specific parameters for the compression test were: a 75 mm diameter probe, a pre-test speed of 2 mm/s, a post-test speed of 10 mm/s, a 2 mm distance from the table, a 20 g trigger force, and a compression distance of 50% of the soft candy's thickness.

2.5. Chemical properties analysis.

Chemical properties were analyzed, including water content [12], ash content, and reducing sugar content, which was determined using the Nelson-Somogyi method. Furthermore, antioxidant activity [13] and total phenolic content (TPC) [14] were also assessed.

2.6. Preference level analysis.

The preference level test involved 20 semi-trained panelists with color, flavor, taste, texture, and overall parameters using a hedonic scale test. The assessment was conducted by scoring a preference level from 1 to 5 (1 = very dislike, 2 = dislike, 3 = somewhat like, 4 = like, 5 = very like). The panel consisted of 8 males and 12 females aged between 20 and 25 years, all familiar with sensory evaluation procedures and frequent consumers of confectionery products. The test was conducted in individual booths under white light, and panelists were instructed to rinse their mouths with water between samples.

2.7. Data analysis.

The obtained data results were analyzed statistically using ANOVA, by utilizing SPSS software (IBM SPSS Statistics version 20.0). If there is a significant difference in each treatment,

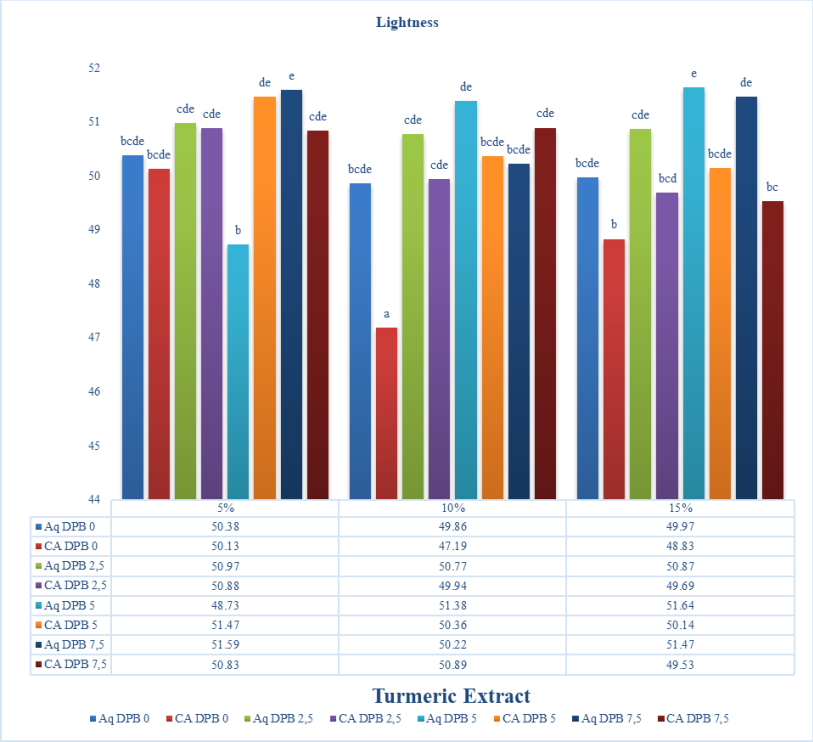
it is continued with the DMRT test. Differences were considered statistically significant when $p<0.05$.

3. Results and Discussion

3.1. Color.

3.1.1. Lightness.

The lightness value is the brightness value of a material from dark (0) to bright (100). Based on the research results, the brightness level (lightness) of turmeric soft candy is presented in Figure 1. The lightness parameters (Figure 1) indicate that both the addition of turmeric extract and the duration of pressurized blanching significantly ($p<0.05$) influenced the lightness values. Specifically, variations in the concentration of turmeric extract at 10% exhibited a notable effect on the lightness value ($P<0.05$). In both the aquadest and citric acid media used for pressurized blanching, an inverse relationship was observed between turmeric extract concentration and the lightness of the soft candy; as the concentration increased, the lightness decreased. In the control treatment, the sample with turmeric extract in Aquadest media showed a non-significant decrease from 50.3 at 5% to 49.86 (10%) and 49.97 (15%). However, the introduction of citric acid in the control treatment resulted in a significant reduction in lightness, from 50.13 (5%) to 48.83 (15%). Similar trends were evident in the pressurized blanching treatments conducted for 2.5, 5, and 7.5 minutes. This phenomenon can be attributed to the inherent color of curcumin pigment, which imparts an orange hue that is incorporated into the soft candy during its production. Consequently, the lightness value of the turmeric soft candy diminishes, resulting in a darker appearance. These findings are consistent with [15], which reported a decrease in lightness with increasing concentrations of turmeric extract in carrageenan-based edible coatings. The lightness of soft candy with variations in the addition of turmeric extract is shown in Figure 1.



	5%	10%	15%
Aq DPB 0	50.38	49.86	49.97
CA DPB 0	50.13	47.19	48.83
Aq DPB 2,5	50.97	50.77	50.87
CA DPB 2,5	50.88	49.94	49.69
Aq DPB 5	48.73	51.38	51.64
CA DPB 5	51.47	50.36	50.14
Aq DPB 7,5	51.59	50.22	51.47
CA DPB 7,5	50.83	50.89	49.53

Figure 1. Soft candy's lightness values with variations in the addition of turmeric extract and duration of pressure blanching. Description: Aq: Aquadest; CA: Citric Acid; DPB: Duration Pressurized blanching.

3.1.2. Redness.

Redness of soft candy with variations in the addition of turmeric extract is presented in Figure 2.

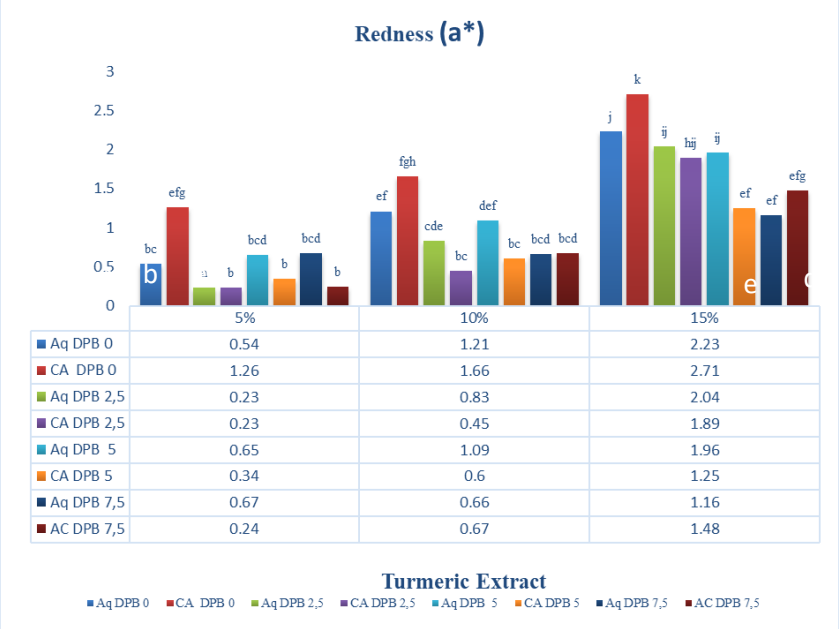
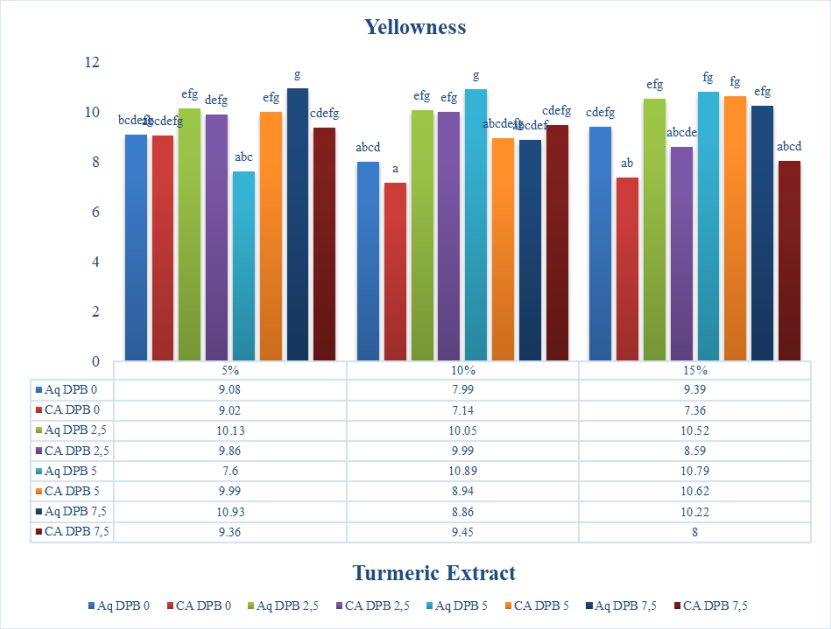


Figure 2. Soft candy's redness values with variations in the addition of turmeric extract and duration of pressure blanching**.** Description: Aq: Aquadest; CA: Citric Acid; DPB: Duration Pressurized blanching.

The redness value indicates the intensity of the red color in a product. Based on Figure 2, the results of the soft candy redness parameter test revealed significant differences (P value < 0.05) between treatments involving turmeric extract addition and pressurized blanching duration. In pressurized blanching using both distilled water and citric acid media, an increase in turmeric extract concentration correlated positively with an increase in the redness value of the soft candy. In samples with turmeric extract in aquadest media, the a* value increased sequentially by 0.54 (5% extract), 1.21 (10% extract), and 2.23 (15% extract) when blanched for 0 minutes. Similarly, samples with turmeric extract in citric acid media exhibited significant increases at concentrations of 5, 10, and 15%, with corresponding values of 1.26, 1.66, and 2.71. Consistent with previous findings, jelly candy containing javanese turmeric extract (*C. xanthorrhiza* Roxb.) demonstrated an increase in redness value from 0.24 at an extract concentration of 0 mL to 2.43 when the extract concentration reached 30 mL [5]. This change in redness is hypothesized to be associated with the gelatinization process during soft candy production, which imparts a reddish hue to the final product. Research by An *et al*. [16] indicates that turmeric rhizomes undergoing the blanching process undergo a color shift towards a more reddish tone. This color change is attributed to the gelatinization of turmeric starch during the steam blanching process. 3.1.3. Yellowness.

Based on Figure 3, the analysis of the yellowness parameter in the soft candy revealed no significant differences (P>0.05) across the various concentrations of turmeric extract and the duration of pressurized blanching. However, in both aquadest and citric acid blanching media, a trend emerged indicating that higher turmeric extract concentration and longer pressurized blanching time led to higher yellowness values in the resulting soft candy. The concentration of the yellow color intensified proportionally with the amount of turmeric extract incorporated into the soft candy formulation. Notably, candy samples with added turmeric extract that were blanched in citric acid media for 5 minutes showed significant differences in b* values: 9.99 (5%

extract), 8.94 (10% extract), and 10.62 (15% extract). Similarly, samples blanched in Aquadest media for 5 minutes showed an increase in b* value from 7.60 (5% extract) to 10.79 (15% extract). Yellowness of soft candy with variations in the addition of turmeric extract is presented in Figure 3.



	5%	10%	15%
Aq DPB 0	9.08	7.99	9.39
CA DPB 0	9.02	7.14	7.36
Aq DPB 2,5	10.13	10.05	10.52
CA DPB 2,5	9.86	9.99	8.59
Aq DPB 5	7.6	10.89	10.79
CA DPB 5	9.99	8.94	10.62
Aq DPB 7,5	10.93	8.86	10.22
CA DPB 7,5	9.36	9.45	8

Figure 3. Soft candy's yellowness values with variations in the addition of turmeric extract and duration of pressure blanching. Description: Aq: Aquadest; CA: Citric Acid; DPB: Duration Pressurized blanching.

These findings align with the research of Tirtayani *et al*., [17], which demonstrated that the addition of turmeric extract to fruit juice beverages imparts a yellow hue attributed to curcuminoid compounds. The color of the soft candy was also influenced by the duration of the blanching process; longer blanching times correlated with a brighter final product color. This effect is likely due to enhanced polyphenol oxidase inactivation with longer blanching, thereby mitigating enzymatic browning and facilitating the stabilization and uniform distribution of the yellow curcumin pigment from the turmeric extract, resulting in a visually brighter soft candy. Soft candy with the addition of turmeric extract is presented in Figure 4.

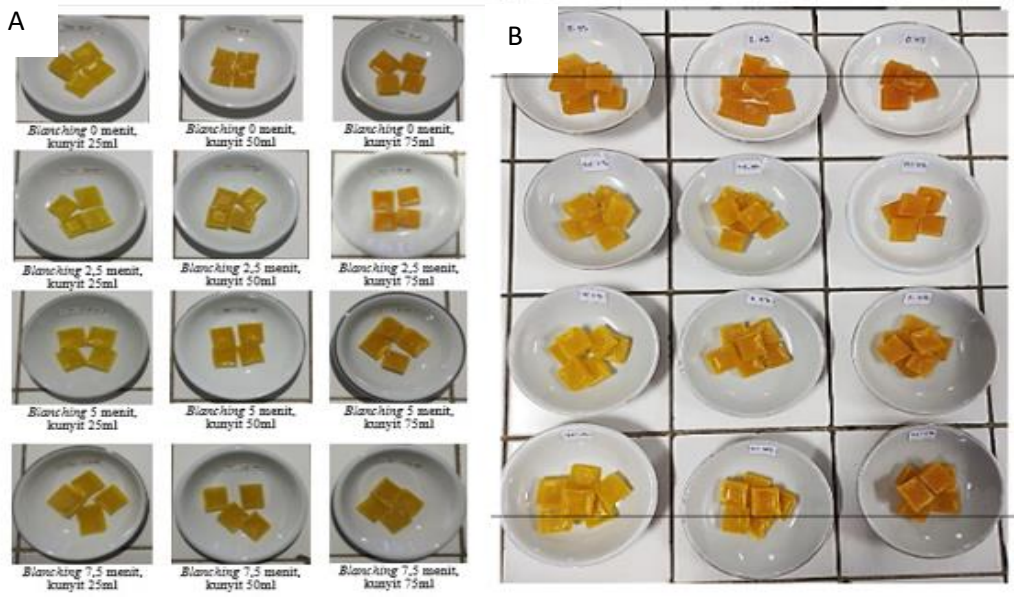
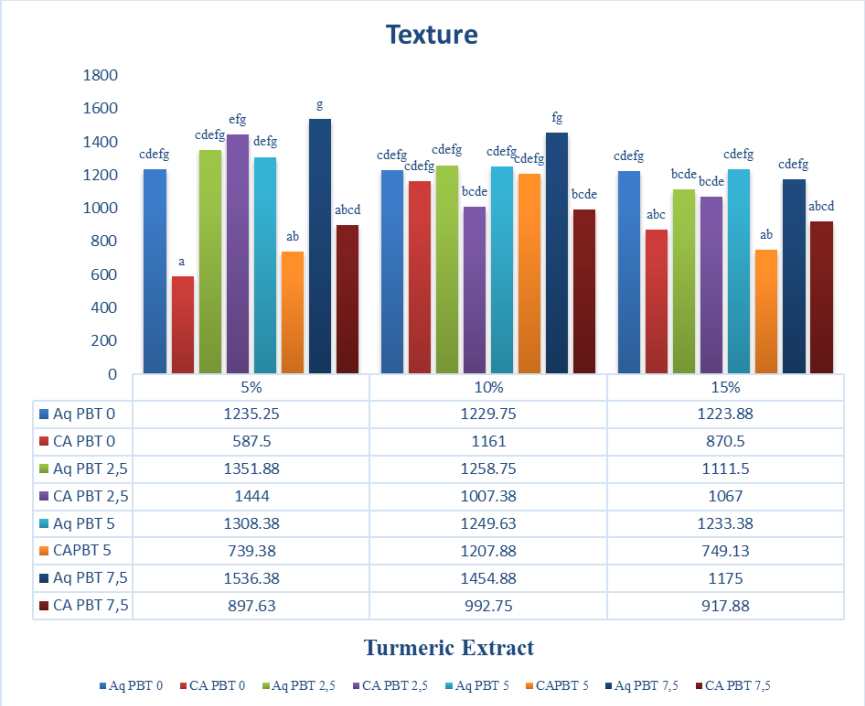


Figure 4. Soft turmeric candy **(A)** soft candy with aquadest blanching treatment; **(B)** soft candy with citric acid blanching treatment.

Prior research has established that blanching treatment can effectively reduce the activity of browning enzymes and preserve the stability of natural pigments, such as curcumin, in food matrices. Reported by [18] that a 1-minute steam blanching of cocoa beans significantly reduced polyphenol oxidase (PPO) enzyme activity and concurrently increased total polyphenol content and antioxidant activity. Furthermore, [16] indicated that blanching treatment for 8 to 10 minutes completely inactivated both PPO and peroxidase (POD) enzymes in turmeric.

3.2. Texture.

Figure 5 presents the texture (peak load) of soft candy as affected by variations in turmeric extract concentration and pressurized blanching duration. Both factors significantly influenced ($p<0.05$) the texture hardness. The treatment with 2.5 minutes of pressurized blanching and 15% turmeric extract produced a peak load of 1111.50 gf, while 7.5 minutes with 5% extract yielded 1175.00 gf, indicating a denser and firmer texture. Pressurized blanching in aquadest media resulted in higher texture values than in citric acid media, likely due to reduced acid hydrolysis of gel-forming polysaccharides. Since the amount of agar used was constant across treatments, texture differences may also be related to the water content of the turmeric extract. Previous studies reported that higher water content in turmeric extract (around 84.7%) can contribute to a softer and more elastic candy texture. Texture values (Peak Load) of soft candy with variations in the addition of turmeric extract are presented in Figure 5.



	5%	10%	15%
Aq PBT 0	1235.25	1229.75	1223.88
CA PBT 0	587.5	1161	870.5
Aq PBT 2,5	1351.88	1258.75	1111.5
CA PBT 2,5	1444	1007.38	1067
Aq PBT 5	1308.38	1249.63	1233.38
CAPBT 5	739.38	1207.88	749.13
Aq PBT 7,5	1536.38	1454.88	1175
CA PBT 7,5	897.63	992.75	917.88

Figure 5. Texture values (Peak Load) of soft candy with variations in the addition of turmeric extract and duration of pressurized blanching. Description: Aq: Aquadest; CA: Citric Acid; DPB: Duration Pressurized blanching.

The addition of agar affects the gel strength of soft candy because agar is a natural hydrogel that forms a three-dimensional network structure when cooled, thus increasing the chewy texture and compactness of the product. The higher the concentration of agar added, generally, the greater the gel strength produced, due to the increase in the number of polysaccharide chains that interact to form stronger gel bonds. Research by Poçan *et al.* [19] found that the addition of sucrose and d-allulose to agar gel affects its physical properties and gel-forming ability, which can be applied in the development of agar-based soft candy products.

In this study, the amount of agar used in all treatments was the same, so the texture of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in citric acid media (0.05%) was influenced by other factors, one of which was the water content of the material. Research by de Ramos *et al.* [20] reported that fresh turmeric rhizomes have an average water content of 84.7%, so treatment with a higher percentage of turmeric extract will produce a thick, soft candy texture or a chewy texture.

3.3. Preference test.

3.3.1. Soft candy with Aquadest blanching media.

The level of preference for soft candy, with variations in the duration of blanching under pressure using Aquadest media and in the addition of turmeric extract, is presented in Table 2.

Table 2. The preference level score of soft candy with variations in the addition of turmeric extract and duration of pressurized blanching in Aquadest media.

PBT (min)	Turmeric extract (%)	Parameter				
		Color**	Flavor**	Taste**	Texture**	Overall**
0 (fresh)	5%	3.24±0.83^{a}	3.60±0.65^{a}	3.64±0.86^{ab}	3.60±0.65^{ab}	3.44±0.71^{a}
0 (fresh)	10%	3.48±0.65^{ab}	3.52±0.65^{a}	3.52±0.87^{a}	3.56±0.77^{a}	3.60±0.65^{ab}
0 (fresh)	15%	4.08±0.70^{c}	3.80±0.50^{ab}	3.76±0.78^{abc}	3.88±0.73^{abcd}	3.84±0.55^{bc}
2.5	5%	3.80±0.71^{bc}	3.96±0.45^{bc}	3.96±0.45^{bcd}	4.08±0.49^{cde}	4.12±0.53^{cd}
2.5	10%	4.08±0.64^{c}	4.12±0.33^{bc}	4.16±0.62^{cde}	4.20±0.50^{cde}	4.16±0.47^{cde}
2.5	15%	4.68±0.48^{e}	4.24±0.52^{c}	4.40±0.76^{e}	4.40±0.58^{e}	4.48±0.65^{ef}
5	5%	3.96±0.84^{c}	3.96±0.54^{bc}	4.08±0.57^{cde}	4.16±0.55^{cde}	3.96±0.54^{cd}
5	10%	4.20±0.65^{cd}	4.00±0.29^{bc}	4.08±0.57^{cde}	3.96±0.68^{bcd}	4.12±0.44^{cd}
5	15%	4.56±0.51^{de}	4.16±0.37^{c}	4.32±0.69^{de}	4.16±0.75^{cde}	4.24±0.60^{de}
7.5	5%	3.96±0.54^{c}	3.92±0.49^{bc}	3.96±0.35^{bcd}	3.84±0.69^{abc}	3.96±0.35^{cd}
7.5	10%	4.08±0.49^{c}	4.00±0.41^{bc}	4.04±0.66^{bcde}	4.20±0.58^{cde}	4.08±0.49^{cd}
7.5	15%	4.56±0.58^{de}	4.24±0.72^{c}	4.40±0.65^{e}	4.28±0.68^{de}	4.56±0.5^{f}

Numbers followed by different letter notations in columns and rows indicate significant differences at a 95% confidence level ($p<0.05$). PBT: Pressure-blanching time; * not significantly different; ** Numbers followed by different lowercase letters indicate significant differences at the 5% level.

3.3.1.1. Color.

Table 2 presents the results of the color preference test of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% Aquadest media, which showed significant differences ($p<0.05$). The color parameters showed that the preferred was soft candy with a blanching time treatment of 2.5, 5, and 7.5 minutes and the addition of 15% turmeric extract with a preference level of 4.68, 4.56, and 4.56, respectively. The longer the blanching time, the color of the soft candy tended to be brighter or lighter, in line with the results of the color analysis. This is because the blanching process, especially at certain pressures and temperatures, can deactivate enzymes such as polyphenol oxidase, which cause non-enzymatic browning reactions, thereby preventing the degradation of turmeric's natural color and maintaining its brightness. On the other hand, the higher the concentration of turmeric extract, the more intense the color of the soft candy becomes, due to a greater amount of curcumin pigment absorbed into the candy matrix. Research by Basha *et al.* [21] showed that blanching treatment and the addition of citric acid in the manufacture of turmeric candy can maintain color and improve sensory acceptance of the product during storage for up to 90 days.

3.3.1.2. Flavor.

Table 2 presents the results of the flavor preference test of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% Aquadest media, which showed significant differences ($p<0.05$). It can be seen that turmeric soft candy with blanching times of 2.5, 5, and 7.5 minutes has the highest flavor preference among panelists, with scores of 4.27, 4.33, and 4.40, respectively. Meanwhile, the treatment without blanching showed a lower flavor preference value of 3.60, which was categorized as neutral. Panelists preferred the flavor of soft candy with the addition of 10-15% turmeric extract. The addition of a lot of turmeric extract will affect the flavor of the soft candy produced. The longer the blanching time, the more preferred the flavor of turmeric because the blanching process can reduce the unpleasant odor or flavor of volatile compounds by destroying the viability of fresh turmeric rhizomes, which is crucial for reducing undesirable raw odors [22]. On the other hand, the higher the turmeric extract concentration, especially 10% to 15%, the stronger and more distinctive the flavor of soft candy becomes, with the highest level of preference recorded at 15% (4.40). According to [23], turmeric rhizome (*Curcuma domestica* L.) contains essential oils that are rich in volatile compounds such as ar-turmerone, α-turmerone, β-turmerone, and zingiberene, which provide a distinctive and slightly spicy flavor (peppery).

3.3.1.3. Taste.

Table 2 presents the results of the taste preference test of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% Aquadest media, which showed significant differences ($p<0.05$). The panelists preferred soft candy that underwent blanching for 2.5, 5, and 7.5 minutes with 10-15% turmeric extract, yielding preference scores of 4.27, 4.33, and 4.47, respectively. The increased preference observed with longer blanching times is attributed to the process's effectiveness in reducing the bitterness imparted by phenolic and unstable volatile compounds, resulting in a cleaner, more palatable product [24]. Higher concentrations of turmeric extract, particularly 10% and 15%, tended to produce a stronger and more distinctive taste that was still favored by the panelists. Bhardwaj *et al*. [25] reported that the methanol extract of *Curcuma caesia* rhizome contains significant levels of minerals, including Fe, Zn, Mn, Ca, and Mg, which contribute to its antioxidant activity and functional potential.

3.3.1.4. Texture.

Table 2 presents the results of the texture preference test of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% Aquadest media, which showed significant differences ($p<0.05$). Analysis of texture parameters revealed that the highest preference scores were given to soft candy blanched for 2.5 and 7.5 minutes with the addition of 15% turmeric extract, achieving texture preference levels of 4.33 and 4.40, respectively. Increased blanching time resulted in a chewier and more stable soft candy texture, likely because the blanching process modifies the material's cell structure, softens fibers, and promotes a more uniform gel formation. Concurrently, higher concentrations of turmeric extract contributed to a more compact soft candy texture. This can be attributed to the blanching treatment's modification of the material's structure, yielding a chewier and more desirable texture, while the turmeric extract aids in the compactness of the gel matrix through interactions with gel-forming compounds such as agar [26].

3.3.1.5. Overall.

Table 2 presents the results of the overall preference test of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% Aquadest media, which showed significant differences ($p<0.05$). The overall preference scores indicated that panelists favored soft candy that underwent blanching for 2.5 and 7.5 minutes, with the addition of 15% turmeric extract, yielding preference levels of 4.48 and 4.56, respectively. The trend suggests that increased blanching time generally enhances overall preference, likely due to improvements in color, suppression of undesirable flavors, and a more desirable texture. Similarly, a higher concentration of turmeric extract (15%) also contributed to increased preference, imparting a characteristic yet palatable turmeric flavor, an appealing yellowish-orange color, and a distinct flavor that enhanced the product's sensory appeal. This specific treatment resulted in soft candy exhibiting a bright, reddish-yellow hue, a noticeable turmeric flavor, balanced turmeric, and sweet taste, a relatively firm texture, and an overall more attractive appearance compared to other formulations. Consequently, the soft candy produced under these preferred conditions was selected for subsequent chemical property analysis.

3.3.2. Soft candy with citric acid blanching media.

The panelist preference level for the organoleptic properties of soft candy with blanching citric acid media is assessed as likes or dislikes, with each being assigned a score. The preference level of soft candy is presented in Table 3.

Table 3. The preference level score of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in citric acid media (0.05%).

PBT (min)	Turmeric extract (%)	Parameter				
		Color**	Flavor*	Taste**	Texture**	Overall**
0	5%	4.56 ± 0.5^{b}	4.20 ± 0.82	4.64 ± 0.57^{b}	4.40 ± 1.04^{bc}	4.60 ± 0.71^{a}
0	10%	4.52 ± 0.71^{b}	4.12 ± 0.78	4.32 ± 0.85^{ab}	4.40 ± 1.12^{bc}	4.40 ± 0.87^{ab}
0	15%	4.24 ± 1.01^{ab}	4.16 ± 0.69	4.16 ± 1.34^{ab}	4.28 ± 0.98^{abc}	4.20 ± 1.00^{ab}
2,5	5%	4.20 ± 0.71^{ab}	4.00 ± 0.87	4.48 ± 0.92^{b}	4.36 ± 0.99^{bc}	4.52 ± 0.71^{a}
2,5	10%	4.55 ± 0.76^{b}	4.00 ± 0.97	4.45 ± 0.51^{b}	3.95 ± 1.19^{ab}	4.25 ± 0.44^{ab}
2,5	15%	4.52 ± 0.77^{b}	4.40 ± 0.76	4.52 ± 1.00^{b}	4.32 ± 0.85^{abc}	4.36 ± 0.86^{ab}
5	5%	4.14 ± 1.07^{ab}	3.86 ± 0.90	3.71 ± 0.95^{a}	3.71 ± 0.95^{a}	3.86 ± 1.35^{a}
5	10%	4.48 ± 0.59^{b}	4.40 ± 0.71	4.24 ± 0.88^{ab}	4.28 ± 1.02^{abc}	4.16 ± 0.94^{ab}
5	15%	4.48 ± 0.51^{b}	4.28 ± 0.68	4.12 ± 1.09^{ab}	4.40 ± 0.76^{bc}	4.20 ± 0.76^{ab}
7,5	5%	3.81 ± 1.08^{a}	3.88 ± 0.89	4.31 ± 0.85^{ab}	4.27 ± 0.92^{abc}	4.02 ± 1.02^{ab}
7,5	10%	4.20 ± 0.91^{ab}	4.16 ± 0.69	4.00 ± 1.04^{ab}	4.44 ± 0.51^{bc}	3.84 ± 1.11^{a}
7,5	15%	4.56 ± 0.87^{b}	4.20 ± 0.96	4.36 ± 0.86^{ab}	4.76 ± 0.44^{c}	4.32 ± 0.85^{ab}

Numbers followed by different letter notations in columns and rows indicate significant differences at a 95% confidence level ($p<0.05$). PBT: Pressure-blanching time; * not significantly different; ** Numbers followed by different lowercase letters indicate significant differences at the 5% level.

3.3.2.1. Color.

Table 3 presents the results of the color preference test of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% citric acid media, which showed significant differences ($p<0.05$). Panelists' preference levels for the color parameters of soft candy containing turmeric extract ranged from 3.81 to 4.56, indicating assessments from neutral to like. The most preferred colors were observed in the treatment without blanching (0 minutes) with 5% turmeric extract, and in the 7.5-minute blanching time with 15% turmeric extract, both scoring 4.56. Longer blanching times generally contributed to more stable and brighter candy colors; excessively long durations could potentially decrease

preference due to natural pigment degradation or visual alterations from mild Maillard reactions. Higher concentrations of turmeric extract resulted in a more intense, vibrant yellow color due to increased curcumin pigment content. Correlation analysis with colorimeter data revealed that colors exhibiting moderate lightness (L = 49.69), low redness (a* = 1.76), and relatively high yellowness (b* = 8.59) were most preferred, suggesting a panelist preference for natural yellow-orange hues that were neither too pale nor too dark. Consistent with this, the preferred and selected soft candy displayed a moderate brightness level (L = 49.69), a redness value of 1.76, and a yellowness value of 8.59, indicating a tendency towards colors that are not overly pale. Prior research has indicated that panelists favored jelly candy samples with natural, bright, and evenly distributed curcumin pigment colors derived from turmeric extract [27].

3.3.2.2. Flavor.

Table 3 presents the flavor parameters of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% citric acid media, which showed significant differences ($p<0.05$). The flavor scores ranged from a low of 3,71 (for 5% turmeric extract with 5 minutes of blanching) to a high of 4.28 (for 15% turmeric extract with 5 minutes of blanching) and showed no significant difference ($p>0.05$). Panelists' preference levels for the flavor of turmeric extract soft candy ranged from 3,86 to 4,40, indicating assessments from like to prefer.

Comparing blanching times, for the 5% turmeric extract, the flavor score decreased notably when blanching was extended to 5 minutes (3.71) compared to nonblanching (4.20) or 2.5 minutes (4.00). A similar, though less pronounced, trend was not consistently observed for the 10% and 15% turmeric concentrations. For instance, with 15% turmeric extract, the flavor score at 5 minutes of blanching (4.28) was among the highest, suggesting that a specific combination of a higher turmeric concentration and a moderate blanching time might be optimal for flavor preference. Overall, while some specific combinations stood out, the data indicate that the interaction between turmeric concentration and blanching time plays a complex role in the perceived flavor of the soft candy, with no single treatment consistently outperforming the others across all conditions.

The addition of water during turmeric extract preparation and the caramelization during cooking resulted in a less-concentrated, distinctive turmeric flavor. The characteristic flavor of turmeric in the soft candy is attributed to the essential oils present in the turmeric extract components. According to [28], turmeric rhizomes have a relatively high essential oil content, ranging from 5-6%.

3.3.2.3. Taste.

Table 3 presents the taste parameters of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% citric acid media, which showed significant differences ($p<0.05$). Panelists' preference scores for taste ranged from 3.71 to 4.64, indicating a range from neutral to like. Increasing the amount of turmeric extract in the soft candy intensified the distinctive turmeric flavor, with panelists generally preferring additions of 5-10% turmeric extract. This preference is likely due to the water used in preparing the turmeric extract, which helps to mitigate the inherent bitterness of turmeric compared to its powdered form. Increasing the turmeric extract concentration to 15% tended to slightly decrease preference, although not drastically, as the turmeric flavor became more dominant and could

introduce a subtle bitter aftertaste. The presence of sugar, a key ingredient in soft candy, also plays a significant role in the overall taste profile, masking any potential bitterness and providing a dominant sweet sensation [27].

3.3.2.4. Texture.

Table 3 presents the texture parameters of soft candy with variations in the addition of turmeric extract and the duration of pressurized blanching in 0.05% citric acid media, which showed significant differences ($p<0.05$). Panelists' preference levels for the texture of soft candy with turmeric extract ranged from 3.71 to 4.76, indicating assessments from like to prefer. The highest texture preference was given to candy blanched for 7.5 minutes with 15% turmeric extract, characterized by a dry outer layer and a soft interior when chewed. The texture of food ingredients can influence their perceived taste. Longer blanching times resulted in a denser and more elastic texture, reaching an optimum at 7.5 minutes, as the material's structure becomes more compact due to the combined effects of heat and pressure. Higher concentrations of turmeric extract also contributed to a firmer and more robust texture, as the extract enhances the gel network through interactions with agar.

A recent investigation has demonstrated that oleo gels composed of xanthan gum and soy lecithin, when combined with turmeric extract, exhibit a rheological profile indicative of solid-like behavior, contributing to enhanced stability and textural characteristics of the gel. Moreover, the incorporation of this formulation into bakery products was observed to reduce hardness and increase porosity, suggesting that turmeric extract has the potential to modulate the textural properties of gels, specifically by imparting a softening effect [29]. According to Umami *et al*, [27], the texture of soft candy is also affected by the type and concentration of gel-forming agents, such as agar, and the duration of heating, which determines the final product's compactness and elasticity.

3.3.2.5. Overall.

The overall parameters of soft candy produced with 0.05% citric acid blanching media showed significant differences ($p<0.05$). Parameters influencing the overall preference for soft candy included color, flavor, taste, and texture. Panelists' overall preference reflected a combined evaluation of these characteristics. The most preferred soft candy was characterized by a moderately bright yellow color, a distinct but not pungent turmeric flavor, a sweet taste with a balanced turmeric flavor, and a soft, nonmushy texture. A blanching time of 2.5 minutes with 15% turmeric extract yielded soft candy with the highest overall preference score.

Citric acid in the blanching media acts as a natural stabilizer for curcumin (the yellow pigment), preserves the flavor profile, and mitigates oxidation-induced damage to active compounds during heating, resulting in a more sensorially appealing final product compared to treatments without citric acid. The inclusion of citric acid in curcumin formulations helps maintain a stable pH, which is essential for the long-term preservation and application of curcumin in food and pharmaceuticals. Curcumin exhibits superior stability in acidic conditions compared to neutral or alkaline environments. Research indicates that curcumin's degradation accelerates with increasing pH, showing significant instability at $pH \geq 7.0$ [30-31]. Conversely, acidic media within the pH range of 2.5 to 5.5 enhance curcumin stability by preserving its molecular structure and reducing degradation.

In contrast, samples blanched in Aquadest tended to exhibit a paler or less stable color, a less consistent turmeric flavor, and a weaker flavor compared to those treated with citric acid. This difference led to lower overall preference scores for the aquadest treatments. Soft candy with 15% turmeric extract and pressurized blanching in 0.05% citric acid media for 2.5 minutes was the most preferred by panelists and was therefore selected for chemical analysis.

3.4. Chemical properties.

Chemical analysis of the selected turmeric soft candy in this research encompassed the determination of moisture content, ash content, reducing sugar content, antioxidant activity, and total phenolic content. These chemical analyses were performed on the chosen sample, which exhibited the most favorable physical and sensory attributes. This optimal sample was obtained from a soft candy formulation incorporating a 15% addition of turmeric extract and subjected to pressure blanching in a citric acid medium (0.05%) for 2.5 minutes. The objective of this analysis was to ascertain the content of bioactive compounds and their associated antioxidant activity. The chemical composition of the turmeric soft candy is presented in Table 4.

Table 4. The chemical composition of turmeric soft candy was subjected to pressure blanching for 2.5 minutes with the addition of 15% turmeric extract.

Parameter	Blanching media		SNI Limits
	Aquadest	Citric acid 0,05%	
Water content (%)	15.54±0.04[a]	16.72±0.311[b]	Max 20%
Ash content (%)	0.97±0.28[b]	0.78±0.13[a]	Max 3%
Reducing sugar (%)	3.55±0.14[b]	2.53±0.03[a]	Max 25%
Antioxidant activity (% RSA)	17.75±0.28[b]	13.29±0.38[a]	-
TPC (mg GAE/g)	5.06±0.08[b]	2.96±0.27[a]	-

SNI: Standar Nasional Indonesia; TPC: Total phenolic content.

3.4.1. Water content.

Based on the chemical analysis, the water content of the selected turmeric soft candy treated with blanching in an aquadest media was 15.54±0.04%, whereas the pressure blanching treatment using a 0.05% citric acid media resulted in a water content of 16.72±0.311% ($p<0.05$). These values remain within the maximum limit of 20% for soft candy as stipulated by SNI 3547-02-2008. The relatively high water content in the product with the addition of turmeric extract may be attributed to the use of water as a solvent in the extraction process, consequently increasing the water content in the product formulation. Furthermore, fresh turmeric has a very high water content, ranging from 80% to 82% [32], which also contributes to the increased water content in the final product. The acidic nature of citric acid media tends to enhance water binding within the product matrix by modifying the structure of the gel-forming agents during heating and aiding moisture retention. Additionally, the reduction in pH due to the use of citric acid can inhibit water evaporation during the cooking process, unlike the Aquadest media, which does not provide this effect. These findings are consistent with the research by [33], who reported a water content in herbal-based soft candy ranging from 13-17%, depending on the type of active ingredient and the processing techniques employed. Therefore, the turmeric soft candy developed is in line with SNI and previous research.

3.4.2. Ash content.

Based on the chemical analysis, the ash content of the selected turmeric soft candy treated with blanching in the aquadest media was 0.97±0.28%, while the blanching treatment using a

0.05% citric acid media resulted in an ash content of 0.78±0.13% ($p<0.05$). Both of these values are below the maximum ash content limit of 3% stipulated in SNI 3547-02-2008, indicating that the soft candy product meets the applicable quality standards. The level of ash content in soft candy is generally influenced by the inorganic or mineral compounds present in the raw materials. Turmeric, as the primary ingredient, is known to have a relatively high ash content, approximately 6-7%, reflecting the presence of minerals such as calcium, phosphorus, and iron [34]. The higher ash content observed in the blanching treatment with Aquadest compared to the citric acid media is likely due to Aquadest's neutral nature, which does not promote mineral dissolution during blanching. Conversely, the weakly acidic citric acid media may dissolve some minerals from the turmeric during blanching, leading to their loss with the blanching liquid and resulting in a lower ash content in the final product compared to the treatment using Aquadest.

3.4.3. Reducing sugar.

Based on the chemical analysis, the reduced sugar content of the selected turmeric soft candy treated with blanching in the Aquadest media was 3.55±0,14%, while the blanching treatment using a 0.05% citric acid media resulted in a reduced sugar content of 2.53±0,03% ($p<0.05$). These values are significantly below the maximum reducing sugar content limit of 25% stipulated in SNI 3547-02-2008, indicating that the soft candy meets the quality standards related to reducing sugar content. The reduced sugar content in soft candy can be influenced by the presence of simple sugar compounds in the raw materials, such as glucose and fructose. Turmeric contains carbohydrate compounds, including reducing sugars like glucose and fructose, which contribute to the reduced sugar value in the final product [28]. The difference in reducing sugar content between the treatments using Aquadest and citric acid is likely due to chemical reactions occurring during the blanching process. The acidic nature of citric acid media can accelerate Maillard reactions and caramelization, converting some reducing sugars into other compounds and thereby reducing the detected sugar content.

3.4.4. Antioxidant activity

Based on the chemical analysis, the selected turmeric soft candy treated with blanching in an aqueous medium showed an antioxidant activity of 17.75±0.28% RSA (Radical Scavenging Activity), while the treatment with 0.05% citric acid media resulted in 13.29±0.38% RSA ($p<0.05$). These values are considered low in the category of antioxidant activity. This low antioxidant activity is likely due to the relatively small concentration of turmeric extract used, which was 15% of 500 g of material. This finding is comparable to a study by [35], which reported an antioxidant activity of 16.51% RSA in soft candy containing 80 g of turmeric and lemon juice.

The difference in antioxidant activity between treatments may be influenced by the type of blanching media used. Blanching for 5 minutes in a citric acid solution has been shown to increase antioxidant activity, which significantly correlates with phenolic content. This increase in phenolic content can enhance the Maillard reaction by providing more reactants [36]. According to a recent study by [37], blanching in organic acid media, such as citric acid, can increase the release of certain bioactive compounds by hydrolyzing glycosides into more biologically active aglycone forms. However, in some cases, excessively prolonged heat treatment can damage antioxidant phenolic compounds and flavonoids.

The low antioxidant activity in turmeric soft candy is also influenced by the thermal processes involved in its production, such as cooking and drying. The drying process at 50-55°C for 70 hours is suspected to contribute to the degradation of antioxidant compounds, especially heat-sensitive phenolic compounds [38]. The difference in results between the aquadest and citric acid treatments likely arises from the effect of the media environment on the stability of antioxidant compounds. Blanching in aquadest media tends to inhibit antioxidant compounds better, as it does not accelerate acid-induced degradation reactions. Conversely, the low pH of the citric acid media can cause degradation of phenolic compounds during blanching and cooking, thereby reducing the measured antioxidant activity in the final product.

3.4.5. Total phenolic content (TPC).

Based on chemical analysis, the total phenolic content of the selected turmeric soft candy blanched in an aqueous medium was 5.06±0,08 mg GAE/g, while the treatment using a 0.05% citric acid medium recorded 2.96±0.27 mg GAE/g. This difference in total phenolic content is closely related to the amount of phenolic compounds originating from the turmeric extract added to the soft candy formulation. Phenolic compounds are key contributors to antioxidant activity, meaning a higher total phenolic content generally indicates greater antioxidant potential [39].

The blanching process is known to affect the total phenolic content of ingredients. In some instances, blanching can increase the bioavailability of phenolic compounds by releasing non-covalently bound compounds or by degrading complex compounds, such as tannins, into simpler phenolics. For example, a study by [36] found that total phenolic content significantly increased with 5 minutes of blanching time, which can enhance the Maillard reaction by providing more phenolic compounds to react with amino acids. However, in this study, blanching with citric acid resulted in lower total phenolic content than blanching with Aquadest. This suggests that the blanching duration and acidic conditions may have caused the degradation of some phenolic compounds sensitive to heat and low pH. Therefore, optimizing blanching parameters is crucial to preserving or enhancing the bioactive compound content in the final product.

4. Conclusions

Soft candies prepared with a 15% turmeric extract addition and pressure blanched for 2.5 minutes in either Aquadest or 0.05% citric acid media were identified as the preferred choices by panelists. These selected soft candies meet the SNI standards for water content, ash content, and reduced sugar. Specifically, the chosen soft candies exhibited antioxidant activities of 17.75% RSA when blanched in Aquadest and 13.29% RSA when blanched in citric acid. Their total phenolic content was 5.06 mg GAE/g for the aquadest-blanched candy and 2.96 mg GAE/g for the citric acid-blanched candy. Turmeric soft candies processed with blanching demonstrate a greater potential as functional foods. These findings suggest that turmeric-based soft candies have promising potential as functional confectionery products that combine consumer acceptability with health benefits.

Author Contributions

Conceptualization, D. and D.P.; methodology, D. and N.A.H.; software, S.W.; validation, D.P. and I.A.F.; formal analysis, N.A.H. and S.W.; investigation, D. and N.A.H.; writing original draft preparation, D., N.A.H., and D.P.; writing review and editing, I.A.F., and S.W.; project

administration, D.P.; funding acquisition, D.P. and S.W. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Data supporting the findings of this study are available upon reasonable request from the corresponding author.

Funding

This research was funded by CV Windra Mekar through an internal research grant.

Acknowledgments

Thanks to CV Windra Mekar for providing research funding.

Conflicts of Interest

The authors declare no conflict of interest.

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