



Milk Caramel Candy Quality by Added Sugar and Red Ginger (*Zingiber officinale var rubrum*)

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ABSTRACT

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Caramel candy or toffee is a confectionery product made from basic sugar, glucose syrup, milk, fat, and salt ingredients. Sugar plays a role in the formation of brown color and caramelization, while the addition of red ginger acts as a flavor enhancer for caramel candy. The reaction results in the production of melanoid and antioxidant compounds. It also affects the taste, texture, aroma, and appeal of caramel candy. This research aimed to analyze the effects of the use and interaction of sugar and red ginger on antioxidants, organoleptic tests, and color L*, as well as chemical (reducing sugar and water content) changes in caramel candy products. This research design used a completely randomized design with a factorial pattern, with factor A adding sugar (0, 5, 10, 15) %; factor B adding red ginger juice (0, 2, 4, 6) %. This research shows that increasing the use of sugar and ginger juice can increase the A* color value, ginger taste, caramel taste, color, ginger, and caramel aroma. Meanwhile, increasing sugar and ginger juice can reduce the L* color value, antioxidant activity, and water content. Adding 15% sugar and 4% red ginger juice is the best for making red ginger juice.

Keywords: Milk caramel candy, red ginger juice, sugar, physicochemical quality.

INTRODUCTION

Milk is a food ingredient produced by dairy livestock such as cows with a high nutritional content because it contains complete food substances such as protein, fat, carbohydrates, minerals, and vitamins needed by humans. However, milk is a perishable food ingredient with a low shelf life, so there needs to be an appropriate solution, namely diversifying food, one of which is caramel candy.

Caramel candy, or toffee, is a confectionery product made from basic ingredients including sugar, glucose syrup, milk (usually condensed milk), fat, and salt, which are processed at temperatures between 100 °C and 121 °C [1]. Sugar plays a key role in creating the chocolate color in caramel candy. Palm sugar is added during the caramel candy process, which generates a brown hue due to the Maillard reaction and caramelization. These reactions produce melanoid compounds and antioxidants, affecting the taste, texture, aroma, and preferences associated with caramel candy. The principle of making milk caramel hinges on the caramelization reaction, a complex interaction involving various processes that render the sugar amorphous (brown). The milk and sugar solution is heated until the water evaporates, leaving only melted sugar. The heating process is deemed complete when the mixture coagulates and is no longer sticky to the pan. A doneness test can be performed by taking a small amount of the mixture and placing it in cold water; if the mixture hardens, the heating process is considered complete.

Further development of caramel candy processing is by adding red ginger. Red ginger (*Zingiber officinale var rubrum*) is a spice plant generally used as a drink or food mixture. Red ginger contains essential oils, zingiberene (zingirona), zingiberol, biabolena, curcumin, gingerol, filandrene, and resin, which are suitable for health and also can maintain food quality, as antimicrobials and antioxidants. When processed, the spicy taste of red ginger can provide a sensation as a lozenge and throat freshener. The use of red ginger is inspired by the taste of a typical South Sulawesi product, namely Sarabba. The addition of red ginger juice itself contains volatile components that provide a distinctive aroma, and oleoresin contains a spicy taste.

The use of red ginger juice as an additive in caramel candy causes changes in the quality of the caramel candy and the compounds that determine the taste. Adding ginger flavor is an innovation to make milk-based caramel to make the product functional. It is important to conduct this research as an initial evaluation of milk caramel sugar with the addition of natural ginger by testing the panelists and its functional properties in the form of antioxidant activity.

MATERIALS AND METHODS

This research was conducted at the Milk Processing Biotechnology Laboratory, Faculty of Animal Husbandry, Hasanuddin University. The measurement parameters used in this study were antioxidants, organoleptic tests, L* & a* colors, and chemical changes (water content and reducing sugar). For organoleptic testing of caramel candy products, 30 panelists aged 17-23 were used.

This research used a Completely Randomized Design (CRD) with a 4 x 4 factorial pattern with three replications. Treatment consists of 2 factors:
Factor A (addition of sugar percentage) (%) of the volume made (w/v); that are A1= 0%; A2= 5%; A3= 10%; A4= 15% Factor B (additional of red ginger juice in % of the volume made (w/v); that are B1= 0%; B2= 2%; B3= 4%; B4= 6%.

Making Caramel Milk Candy

Making Red Ginger Juice

Red ginger was cleaned from the remaining soil with a brush and water. Once clean, it was cut into small pieces to make it easier to crush by blending. Red ginger was blended until smooth by adding water in a ratio of 1:4, and then the extract liquid was separated from the dregs by filtering.

Caramel Candy Making Process

Making candy begins by mixing and heating milk, sugar, and red ginger juice according to the amount of treatment at a temperature of 100°C with continuous stirring until a thick liquid forms. Next, add gelatin flour while continuing to stir. Heating is stopped after reaching the desired viscosity. To know if the mixture has caramelized, put a little of it in a container filled with cold water; if the mixture forms a complete circle, it is ready to be molded. The dough is allowed to cool and harden in the mold. This process is repeated according to the number of replications used in the research.

Making Milk Caramel Candy

In this study, milk caramel was made using whole cream milk, granulated sugar in each treatment, agar powder, and red ginger juice. The composition of ingredients for making milk caramel candy is in Table 1.

Table 1. Composition of ingredients for milk caramel candy at different concentrations of added sugar and red ginger

MATERIAL (%)	1	2	3	4
Milk	99.30	99.30	99.30	99.30
Jelly	0.7	0.7	0.7	0.7
Total	100	100	100	100
Sugar	0	5	10	15
Red ginger	0	2	4	6

Note: Sugar and red ginger are added to the total ingredients used.

RESULTS AND DISCUSSIONS

The results of the further test of the average sugar addition treatment showed that the aroma of ginger in the treatment without sugar and ginger (B1) was different from the treatment using 2-6% ginger (B2-B4). The smell of ginger increased along with the addition of ginger juice. The ginger aroma in milk caramel candy is 1.30-3.83%, indicating a slight ginger aroma. In contrast, Sulistyowati et al. [2] found that durian-flavored milk caramel candy has a 4-5% aroma by panelist evaluation. This difference arises because a higher concentration of ginger effectively reduces the unpleasant odors in the candy, as ginger contains essential oils that influence the resulting aroma. However, adding white ginger to soy milk caramel candy causes the pleasant

scent to diminish slightly [3]. Therefore, the higher the concentration of ginger, the more it can mitigate the candy's undesirable odor. This effect results from the essential oil content in ginger, which uniquely shapes the overall aroma.

Table 2. Average value of ginger aroma (%), milk caramel candy with percentage of sugar, and red ginger juice

Added Ginger(%)	Added Sugar (%)				Average
	A1 (0)	A2(5)	A3(10)	A4(15)	
B1(0)	1.30±0.83 ^{ab}	1.50±0.93 ^b	2.20±1.39 ^b	2.33±1.29 ^b	1.83 ± 1.21
B2(2)	2.13 ± 1.27 ^a	2.96±1.44 ^{ab}	3.23±1.61 ^{ab}	2.96±1.44 ^{ab}	2.82 ± 1.49
B3(4)	2.50±1.50 ^a	3.50±1.50 ^{ab}	3.36±1.69 ^{ab}	3.10±1.29	3.11 ± 1.53
B4(6)	3.06±1.36 ^b	3.20±1.44 ^{ab}	3.76±1.38 ^{ab}	3.83±1.41 ^{ab}	3.46 ± 1.42
Average	2.25±1.40	2.79±1.54 ^{ab}	3.14±1.61 ^{ab}	3.05±1.45 ^{ab}	2.81 ± 1.54

Ginger contains essential oils, which are aromatic compounds. The essential oil content of red ginger is approximately 2.58-2.72%, calculated based on dry weight. Red ginger essential oil is yellow, slightly thick, and has a distinctive aroma: warm, spicy, and somewhat sweet. The unique aroma of ginger can be a special draw for candy. Ginger candy can appeal to those who enjoy the smell of ginger or seek the benefits of ginger, such as warming the body, reducing nausea, and relieving pain [4].

Milk Caramel Candy Aroma

Table 3 presents the caramel aroma value in milk caramel candy, which is 2.16-4.00, which means it does not have a caramel aroma or has a caramel aroma. This is caused by added sugar. Apart from giving the candy a sweet taste, the caramelization reaction also provides the candy with a caramel aroma. Adding sugar can give a sweet taste and provide color and aroma to bread because of a caramelization reaction during processing [5]. In making bread, sugar reacts to the formation of brown color, which is caused by the Maillard reaction and caramelization. This reaction will affect the texture, taste, preferences, and aroma.

The addition of sucrose can cause the distinctive aroma of milk to disappear. This is because sugar dissolves in water and turns into invert sugar, namely glucose and fructose, where the hydroxyl (OH) group in invert sugar will bind to the hydrocarbon (CH) group of caproic and caprylic fatty acids. Heating will result in degrading dyes in food ingredients, resulting in changes in texture, taste, color, and preferences. Caramelization occurs when carbohydrates are heated at high temperatures, producing caramel's characteristic aroma and color [6].

Adding sucrose to milk caramel candy is intended to obtain the characteristic caramel aroma from the sugar and milk protein reaction at high temperatures. By processing milk into caramel, the intensity of the typical milk aroma can be reduced so that consumers who do not like the typical milk aroma can also consume the processed product. Caramelization occurs when carbohydrates are heated at high temperatures, producing a characteristic caramel aroma and color. The Maillard reaction in food can create taste and aroma [7].

Table 3. Average value of Caramel Aroma (%), milk caramel candy with percentage of sugar, and red ginger juice

Added Ginjer (%)	Added Sugar (%)				Average
	A1(0)	A2(5)	A3	A4	
B1 (0)	2.56 ± 1.45	3.10 ± 1.39	4.00±1.48	3.76 ± 1.45	3.35 ± 1.53
B2 (2)	2.16 ± 0.98	3.76 ± 1.16	3.43 ± 1.50	3.20±1.39	3.14 ± 1.39
B3 (4)	2.76 ± 1.35	3.20 ± 1.09	2.93 ± 1.22	3.50±1.43	3.10±1.29
B4 (6)	2.46 ± 1.19	2.66 ± 1.39	2.90 ± 1.34	3.40 ± 1.56	2.85 ± 1.41
Average	2.49 ± 1.26	3.18±1.31	3.31 ± 1.44	3.46 ± 1.46	3.11 ± 1.42

Milk Caramel Candy Flavor

The taste value for milk caramel candy ranges from 1.23 to 2.96, indicating that it is not sweet or only slightly sweet. This occurs due to insufficient sugar being added to the candy. A crucial factor in candy-making is the incorporation of sugar. If too little sugar is used, the resulting candy lacks sweetness and is soft; conversely, if too much is added, the candy becomes overly sweet and complex. To produce high-quality candy, a ratio formulation of passion fruit and papaya juice at 80% to 20%, with a sugar concentration of 70%, is utilized [8].

Table 4. Average value of Caramel Taste (%), milk caramel candy with percentage of sugar, and red ginger juice

Added Ginger (%)	Added Sugar (%)				Average
	A1 (0)	A2 (5)	A3 (10)	A4 (15)	
B1 (0)	1.23 ± 0.56a	2.43±1.56ba	1.83±1.14ba	1.90±1.06ba	1.85±1.20
B2 (2)	1.86±1.04ab	2.36±1.27b	2.83±1.01b	2.26±0.90b	2.33 ± 1.11
B3 (4)	2.10±1.09ab	2.96±1.06b	2.40±1.19b	2.90±1.29b	2.59 ± 1.20
B4 (6)	2.16 ± 1.36a	2.79±1.04b	3.63±1.29b	3.56±1.30b	3.04 ± 1.38
Average	1.84 ± 1.10	2.63 ± 1.26	2.67 ± 1.32	2.65±1.30	2.45±1.30

Apart from providing a sweet taste, adding sucrose to milk caramel candy is also intended to obtain a distinctive caramel aroma, which arises from the reaction of sugar and milk protein at high temperatures, and to get milk caramel candy with a desired consistency. Excessive use of sucrose will result in brittle or hard milk caramel candy. Meanwhile, adding glucose syrup can produce a product with a softer texture because it has properties that are difficult to crystallize [9].

The addition of red ginger can also help reduce the sweet taste of candy, because ginger contains the bitter taste of shogaol. The decrease in sweetness is due to the addition of white ginger, which contains a bitter taste. The decline in sweetness in candy can be influenced by adding other ingredients that will affect the taste, such as sour and bitter [10]. The main component of ginger oleoresin, which causes the bitter taste, is shogaol.

Milk Caramel Candy Ginger Flavor

The taste value for milk caramel candy ranges from 2.26 to 4.50, indicating a spectrum from slightly spicy to spicy. Adding ginger can provide a somewhat tangy flavor due to gingerol and shogaol. The primary compounds responsible for the zesty taste of red ginger are gingerol and shogaol [11]. Notably, the gingerol content in red ginger is higher than in other types of ginger [9]. Ginger's characteristic smell and aroma arise from a blend of zingerone, shogaol, and essential oils, constituting about 1-3% of fresh ginger. Zingerone has a milder spiciness and contributes a sweet taste.

The influence of compounds in ginger can give candy a distinctive ginger taste. Ginger contains oleoresin, which consists of zingerol, shogaol, and resin components, which cause ginger's spicy taste [12]. Chemical compounds, temperature, concentration, and interactions with other flavor components influence taste.

Table 5. Average value of ginger taste (%), milk caramel candy, with percentage of sugar, and red ginger juice

Added Ginger (%)	Added Sugar (%)				Average
	A1(0)	A2(5)	A3(10)	A4(15)	
B1(0)	2.26 ± 1.31	3.40 ± 1.10	4.10 ± 1.06	4.50±1.13	3.56 ± 1.42
B2(2)	2.50±1.22	3.16 ± 1.39	3.80 ± 1.44	4.16 ± 1.44	3.40±1.50
B3(4)	2.76 ± 1.07	3.20 ± 1.37	3.93 ± 1.20	3.76 ± 1.22	3.42 ± 1.29
B4(6)	3.03 ± 1.29	3.33 ± 1.24	3.36 ± 1.15	4.33 ± 1.06	3.51 ± 1.27
Average	2.64 ± 1.24	3.27 ± 1.26	3.80±1.24	4.19 ± 1.23	3.47 ± 1.37

The taste of food results from a combination of smell and taste. Consumers can distinguish one type of food from another, especially when paired with the feelings of consistency and texture in the mouth. Heating can lead to the degradation of flavor compounds and the physical properties of food ingredients. Adding ginger introduces a slightly spicy flavor. Gingerol is characterized by its instability at high temperatures, which causes it to dehydrate into shogaol, producing a pungent taste [13].

Milk Caramel Candy Color

Based on the results obtained in Table 6, the color value of milk caramel candy is 1.80-5.36, indicating that it is slightly yellow-brown. This is influenced by the caramelization reaction that occurs in sugar. As the cooking temperature rises, the resulting color value will increase [14]. The brownish-yellow hue of this milk candy is also affected by the caramelization reaction in sugar. Caramelization creates a brown color when sugar is heated, as in caramel confectionery.

A higher concentration of ginger can cause the candy to have a darker color because ginger contains brownish phenol compounds. The brown color of ginger is also caused by caramelization and Maillard reactions. If materials containing protein and sugar are heated, they produce a Maillard reaction. The protein contained in T1 to T4 shows an increase in low amounts along with the addition of a higher concentration of white ginger because ginger also contains protein [15].

Table 6. Average color value (%) of milk caramel candy with the percentage of sugar and red ginger juice

Added Ginger (%)	Added Sugar (%)				Average
	A1(0)	A2(5)	A3(10)	A4(15)	
B1(0)	1.80±1.80a	4.06±1.36b	4.93±1.01c	5.13±0.89db	3.98 ± 1.70
B2(2)	2.33±2.33a	4.06±0.94b	4.96±0.85c	5.26±0.90db	4.15 ± 1.48
B3(4)	1.93±1.93a	4.34±1.11b	4.96±0.71c	5.10±1.12db	4.08 ± 1.63
B4(6)	3.43±3.43a	4.33±1.09b	4.66±1.06c	5.36±0.96db	4.45±1.30
Average	2.37±2.37	4.20±1.13b	4.88 ± 0.91	5.21 ± 0.97	4.16 ± 1.54

The Maillard reaction involves the browning of carbohydrates, particularly reducing sugars, and primary amine groups. This reaction produces a brown material, which can often be undesirable or even indicate a decrease in quality. Browning food ingredients containing carbohydrates can accelerate with higher heating temperatures, leading to the reduction of sugar components to form brown compounds. The Maillard reaction occurs from the interaction of the amino groups in proteins and the carboxyl groups in reducing sugars, producing a brown material. In contrast, caramelization arises from the reaction between sugar and heat [16].

Milk Caramel Candy Favorite

Organoleptic assessment with hedonic tests is one type of acceptance test. In this test, panelists are asked to express their responses regarding likes or dislikes and state their level of likes and dislikes. These levels of liking are referred to as a hedonic scale, for example, like very, very like, like very much, like, somewhat like, neutral, somewhat dislike, strongly dislike, and immensely, very dislike. These levels of dislike are called the hedonic scale [17].

Flavor

Based on the results obtained in Table 7, the liking value for milk caramel candy is between 2.96 and 4.20, indicating a somewhat favorable opinion. The more sugar added, the greater the liking value, while adding more ginger decreases this value. This is because sugar creates a sweet candy. However, adding a large amount of sugar and ginger produces milk caramel candy that is slightly bitter. This bitterness is due to the essential oil components in red ginger, which impart a bitter and spicy flavor. The decrease in preference for the taste of milk caramel candy is thought to be related to the aroma and taste of ginger added to the treatment. The panelists preferred caramel candy with milk aroma over caramel with other ingredients [18].

Colors L* and A* Milk Caramel Candy

Table 8 data indicates that as more sugar and ginger are added, the L* color value decreases by 49.41%. Conversely, as less sugar and ginger are added, the L* value increases by 82.33%, producing bright or clear caramel milk candy.

Table 7. Average value of liking (%) milk caramel candy with percentage of sugar and red ginger juice

Added Ginger (%)	Added Sugar (%)				Average
	A1(0)	A2(5)	A3(10)	A4(15)	
B1(0)	3.06 ± 1.43	3.36 ± 1.40	4.20 ± 1.29	4.13 ± 1.27	3.69 ± 1.42
B2(2)	2.93 ± 1.74	3.40±1.32	3.70 ± 1.60	3.90 ± 1.29	3.48 ± 1.52
B3(4)	3.16 ± 1.46	3.66 ± 1.37	3.23 ± 1.50	3.93 ± 1.11	3.50±1.39
B4(6)	2.96 ± 1.37	3.60±1.30	3.46 ± 1.19	3.70 ± 1.53	3.43 ± 1.37
Average	3.03 ± 1.49	3.50±1.34	3.65±1.43	3.91 ± 1.30	3.52 ± 1.42

The ingredients in milk that play an important role in making milk caramel candy are lactose and protein. When subjected to heat, milk's protein and sugar (lactose) produce a browning reaction, commonly known as the Maillard reaction. The effect of milk components during heating is a reduction in nutritional content, as the heating occurs at a high temperature of around 120°C for an extended period. The proteins in milk can influence the elasticity of the candy. In addition to protein, the water content of milk is also believed to affect the characteristics of milk caramel candy. Low water content can produce a hard texture, while high water content can create a soft texture in the milk caramel candy. Therefore, the higher the L value, the brighter the resulting color, and vice versa [19].

Color L* Milk Caramel Candy

Making milk candy involves sugar and milk, which influence the formation of crystals and cause the candy to turn brown due to the browning reaction (Maillard reaction) [20]. The principle of candy-making lies in the heating process; if the temperature is not appropriate, the candy produced will not form. An essential factor to consider when making candy is the cooking time required to achieve the desired product consistency. The sugar concentration in the mixture plays a crucial role in determining the final product's texture. Sugar also helps define the characteristics of the candy. If the candy contains a high level of reducing glucose, it will tend to be sticky [21].

An A on milk caramel candy results from caramelization and Maillard reactions. When materials containing protein and sugar are heated, they undergo a Maillard reaction. The protein levels in T1 to T4 show a slight increase with higher concentrations of white ginger, as ginger also contains protein. One of the rhizome plants that contains protein is ginger, which has 1.5%. Therefore, the greater the protein content in caramel candy, the more intense the Maillard reaction will be, resulting in a darker color with a higher concentration of white ginger [22].

Color A* Milk Caramel Candy

The caramelization reaction is a non-enzymatic browning reaction. The caramelization reaction occurs due to the interaction of sugars at high temperatures (800 °C), above the melting point [23]. This reaction occurs when sugar is heated in acids, bases, or without water. This is different from the Maillard reaction, which occurs due to the presence of water, but both produce a brown color change [24]

Table 8. Average color value L* and A* (%) of milk caramel candy with percentage of sugar and red ginger juice

SUGAR(%)	GINGER JUICE(%)	Color L*	Color A*
A1(0)	B1(0)	82.30±0.00	4.42 ± 0.04
	B2(2)	82.33±0.01	2.97±0.03
	B3(4)	82.17±0.00	2.77 ± 0.05
	B4(6)	82.18±0.01	3.27±0.00
A2(5)	B1(0)	64.70±0.01	7.47±0.00
	B2(2)	68.94 ± 0.05	6.46±0.00
	B3(4)	69.12±0.00	6.29±0.94
	B4(6)	67.85±0.00	7.89±0.00
A3(10)	B1(0)	56.11±0.11	11.77±0.01
	B2(2)	53.38±0.25	10.09±0.00
	B3(4)	56.47±0.05	10.75±0.00
	B4(6)	54.34 ± 0.07	11.07±0.03
A4(15)	B1(0)	53.24 ± 0.04	11.86±0.00
	B2(2)	49.83±0.23	11.99±0.01
	B3(4)	54.52±0.47	11.90±0.00
	B4(6)	49.41±0.01	12.85±0.03

The more fruit juice (sugar) added to the candy, the darker brown the resulting candy becomes. According to Anggraini et al. [18], a caramelization process will occur [18] if sucrose is continuously heated to its melting point of 160°C. The reaction is a non-enzymatic browning reaction, namely a caramelization reaction, which causes the candy to darken. This process means that each sucrose molecule is broken down into glucose and fructose, where high temperatures can remove water molecules from the sugar molecules, resulting in the formation of glucose and fructose (dehydration). After the breakdown and dehydration process, there is a polymerization reaction, namely the formation of colored polymer components, causing the solution to be dark in color [25].

Antioxidant Activity of Milk Caramel Candy

Antioxidants are compounds essential in inhibiting oxidative reactions in the body, which can cause various diseases. Increased oxidative stress can reduce the body's defense system, so antioxidants are needed. Milk caramel candy using palm sugar and red ginger is known to have relatively high antioxidant content. Table 9 presents the average value of antioxidant content in milk caramel candy with different percentages of palm sugar and red ginger juice.

The results of the antioxidant test research on milk caramel candy in Table 9 show that the percentage range of antioxidant activity produced is between 28.28% and 60.74%. The highest value was in treatment A4 (15%) and B1 (0%), while the lowest value was in treatment A1 (0%) and B1 (0%). This shows that the antioxidant activity of milk caramel candy increases with the addition of palm sugar.

Antioxidant activity will be higher as the addition of white ginger extract increases. This is because white ginger is a spice plant that can provide antioxidant effects, so the more white ginger extract is added, the higher the antioxidant activity. Ginger is an herbal plant that has beneficial antioxidant effects due to its content of various bioactive substances. The increase in antioxidant activity in soy milk caramel candy is in line with the rise in phenol content in it because phenol from white ginger is the main compound that acts as an antioxidant, so the more white ginger extract that is added, the more phenol content will increase and at the same time increase the antioxidant activity of caramel candy soy milk. Ginger's ability as a natural antioxidant is influenced by ginger oleoresin, which contains phenolic compounds in shogaol and gingerol. The antioxidants found in white ginger are active compounds that, when consumed, can prevent oxidation events due to free radicals in the human body [26].

Antioxidant activity and total phenolic content are related to each other. If there is an increase in antioxidant activity, the total phenol content in the food will be greater. Factors influencing total phenol are the compound molecules and the arrangement of hydroxyl groups. The greater the antioxidant activity in plants, the greater the phenolic content. Antioxidants are compounds that can counteract free radicals during the body's metabolic processes. Palm sugar has a high water content, which causes yeast activity to grow and develop in the product. The yeast in the product would degrade sugar, especially dextrose and levulose. This is the reason for the higher production content of palm sugar due to the high water content [27].

Table 9. Average value of antioxidant activity (%) of milk caramel candy with the percentage of sugar and red ginger juice

SUGAR	Ginger Juice	Antioxidant
A1	B1	28.28±0.15
	B2	51.23±2.37
	B3	51.27±0.71
	B4	51.70±0.50
A2	B1	46.15±0.65
	B2	31.71 ± 0.25
	B3	33.84 ± 0.64
	B4	52.09±0.40
A3	B1	38.20±3.27
	B2	53.51±0.29
	B3	55.18±0.23
	B4	55.76±0.29
A4	B1	60.74 ± 0.93
	B2	42.35±0.77
	B3	44.06±1.32
	B4	47.07±0.46

Table 10. Average value of sugar reduction for milk caramel candy with different percentages of palm sugar and red ginger juice

Red Ginger Sari (B)	Palm Sugar (A)				Average
	A1	A2	A3	A4	
B1	11.33 ± 0.57	11.66 ± 0.57	13.00±0.00	13.33 ± 0.57	12.33 ^b ±0.98
B2	11.33 ± 0.57	11.66 ± 0.57	13.66 ± 0.57	12.66 ± 0.57	12.33 ^b ±1.07
B3	11.00±1.00	11.33 ± 0.57	12.00±0.00	12.66 ± 0.57	11.75 ^a ±0.86
B4	11.00±1.00	11.66 ± 0.57	13.00±0.00	12.66 ± 0.57	12.08 ^{ab} ±0.99
Average	11.16 ^a ±0.71	11.58 ^a ±0.51	12.91 ^b ±0.66	12.83 ^b ±0.57	

Water content

The research results of the water content test for milk caramel candy in Table 11 show that the percentage range for the resulting water content test is between 17.22% and 41.79%. The highest value was in treatment A1 (0%) and B2 (2%), while the lowest value was in treatment A4 (15%) and B1 (0%). The water content value in milk caramel candy continues to decrease with increasing sugar use in treatments A1 (0%) to A4 (15%) with an average value of 39.375% -18.46% and red ginger juice at the percentage of B1 (0%) to B4 (6%) with an average value of 26.37%-28.66%. This shows that increasing sugar use will result in decreasing water content. However, as the use of red ginger juice increases, the water content of the candy increases.

Table 11. Average value of water content (%) of milk caramel candy with different percentages of palm sugar and red ginger juice

Red Ginger Sari (B)	Palm Sugar (A)				Average
	A1	A2	A3	A4	
B1	39.29±3.11	28.24 ± 0.40	20.73 ± 0.12	17.22 ± 0.22	26.37 ^a ±8.93
B2	41.79±1.97	27.38 ± 0.42	22.04 ± 0.25	16.65±0.40	26.96 ^a ±9.82
B3	39.11 ± 1.52	27.56 ± 1.85	21.10 ± 0.55	20.09 ± 0.41	26.97 ^a ±7.98
B4	38.80±3.43	26.77±2.61	29.20±15.26	19.87 ± 0.13	28.66 ^a ±9.79
Average	39.75 ^a ±2.56	27.48 ^b ±1.49	23.27 ^c ±7.44	18.46 ^d ±1.63	

Using palm sugar in milk caramel candy can reduce the water content of the palm sugar. Palm sugar has a high water content, which is indicated by a moist texture [28]. However, the water content in palm sugar can decrease due to the cooking process. The higher the cooking temperature, the more water evaporates, so the water content is lower. Low water content produces a harder or drier texture [29, 30].

CONCLUSIONS

Based on the research, it can be concluded that increasing the use of sugar and ginger juice can increase the value of color A*, ginger flavor, caramel flavor, color, ginger aroma, and caramel aroma. Expanding the use of sugar and ginger juice can decrease the value of color L*,

antioxidant activity, and water content. The use of 15% sugar and 4% ginger in the formulation of milk caramel candy is the best in terms of physicochemical characteristics.

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AUTHORS' CONTRIBUTIONS

All researchers were involved in this research and in manuscript preparation, revision, and publication.

COMPETING INTERESTS

The authors have to declare that they have no competing interests.

ETHICAL CLEARANCE

This research does not use experimental animals as research objects.

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