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Sensory evaluation of palm sugar candy from arenga sap water and agarwood leaves infusion using a 9-point hedonic scale

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ABSTRACT

Agarwood (Gyrinops versteegii) and sugar palm (Arenga pinata) are essential non-timber forest products from Lombok Island, Indonesia. This research aims to conduct a 9-point hedonic scale on palm sugar candy made from a formulation of agarwood leaves infusion and Arenga sap water with different proportions. Four formulations are used as a treatment in this research, including F1 (agarwood infusion: sap water=1:2), F2 (agarwood infusion: sap water=1:3), F3 (agarwood infusion: sap water=1:4), and F4 (agarwood infusion: sap water=1:5). The mixture was heated for 60 minutes until the volume was 8% of the initial volume, and then it became viscous and solidified in the silicone candy mould. The 9-point hedonic scale is used in this research range from 9 (Like extremely) to 1 (Dislike extremely). Four statistical approaches were used, including Kruskall-Walllis, Freidman, ANOVA-CRD, and ANOVA-RCBD. Duncan Multiple Range Test and spider chart analysis were also used as analytical tools. Respondents were evaluated in 4 parameters: appearance, aroma, taste, and texture. The proximate assay shows that total carbohydrates dominated palm sugar candy with a proportion of 87%. The hedonic test shows that treatment significantly affects numerical hedonic scores given by the respondents in all statistical approaches. F3 has the highest numerical hedonic score in aroma and taste parameters, while F4 has the highest appearance and texture parameters. However, based on the overall evaluation, F4 is the best formulation. It could be concluded that a mixture of agarwood leaves infusion and Arenga sap water with a proportion 1 of 5 was the best formulation to produce palm sugar candy with the highest sensory evaluation score based on a 9-point hedonic scale. Further research about nutritional adequacy rate is essential to support the commercialization of this product.

Keywords: agarwood; hedonic; palm-sugar; sap-water

INTRODUCTION

Lombok Island, Indonesia, has a potential non-timber forest food that can be utilized into food. Food products from forest areas have several benefits, including being naturally grown, using no chemical pesticides orchemical fertilizers, and having specific health-beneficial effects

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(Sardeshpande & Shackleton, 2019). However,the potency of food products from the forests has rarely been explored because this product has been related to a primitive way of life conducted by several indigenous people (Gan et al., 2020).

Arenga pinata is a non-timber forest product in Lombok Island that has been utilized by forest farmers(Hidayat & Soimin, 2021). The forest farmers mainly harvest sap water from this plant to produce palmSugar products (Victor & Orsat, 2018). This product is considered an essential plant-based sweetener from non-timber forest products (Kumar et al., 2021). However, palm sugar products in Lombok lack innovation and are primarily sold in bulk pieces of jaggery as a part of local cuisine (Haryoso et al., 2020)

Preliminary research on Arenga sap water mixing with multi-purpose tree species infusion has produced a palm sugar candy product, an innovative culinary product from A. pinata (Baharudin et al., 2023). However, this research has yet to apply optimization of the proportion of arenga sap water and leaves infusion in the mixture. The consequences of these inappropriate proportions of the mixture can affect the taste and flavour of palm sugar candy, which affects the quality.

The correct proportion of arenga sap water and leaves infusion could be an essential formula to produce palm sugar candy with excellent taste and flavor. This adjustment can also affect the consistency of palm sugar candy, improving the appearance quality. Thus, exploring the composition of additional ingredients in palm sugar is essential to improve the taste, flavour, and appearance of palm sugar candy for a better quality of this product. (Upadhyaya et al., 2023).

Agarwood from Gyrinops versteegii species is one of the most essential non-timber forest products from Lombok Island (Wicaksono et al., 2019). Leaves infusion of this species is an essential herbal product called gyrinops tea (Wangiyana et al., 2022). Phytochemical screening and antioxidant assay have revealed that Gyrinops tea contains several compounds with health-beneficial effects (Wangiyana et al., 2021). This data makes agarwood leaves infusion from this species highly potential to be mixed with arenga sap water to produce palm sugar candy with excellent flavor, taste and appearance.

Palm sugar candy from a mixture of arenga sap water and agarwood leaves infusion is an innovative new product from Lombok Island. Research and development of new culinary products should be based on scientific methods for precision data (Świąder & Marczewska, 2021). One excellent scientific method for researching and developing culinary products is a sensory evaluation based on a hedonic test(Mazur et al., 2018). Most hedonic test for culinary products in Indonesia uses a 5-point hedonic scale(Adrianar et al., 2015; Batubara et al., 2018; Larasati & Issutarti, 2017). On the other hand, most hedonic tests for international culinary products use the

9-point hedonic scale. Compared to the 5-point hedonic scale, the 9-point hedonic scale uses a wide range of measurements with high sensitivity to reveal the different evaluations of respondents (Feng & O'Mahony, 2017; Wichchukit & O'Mahony, 2015, 2022; Yang & Lee, 2018). The 9-point hedonic scale is a robust sensory evaluation for culinary products. However, this type of test is rarely conducted on local Indonesian culinary products (Wangiyana et al., 2023).

This research aims to conduct a 9-point hedonic scale on palm sugar candy made from a formulation of agarwood leaves infusion and Arenga sap water with different proportions. This research can provide helpful consumer preference data, which is essential for the development of palm sugar candy products as innovative culinary products from Lombok Island.

METHODOLOGY

The processing method summary of the palm sugar candy from agarwood leaves and arenga sap water is described in Figure 1. This method involves 3 primary processes: making agarwood infusion, processing arenga sap water, and mixing agarwood infusion with arenga sap water.

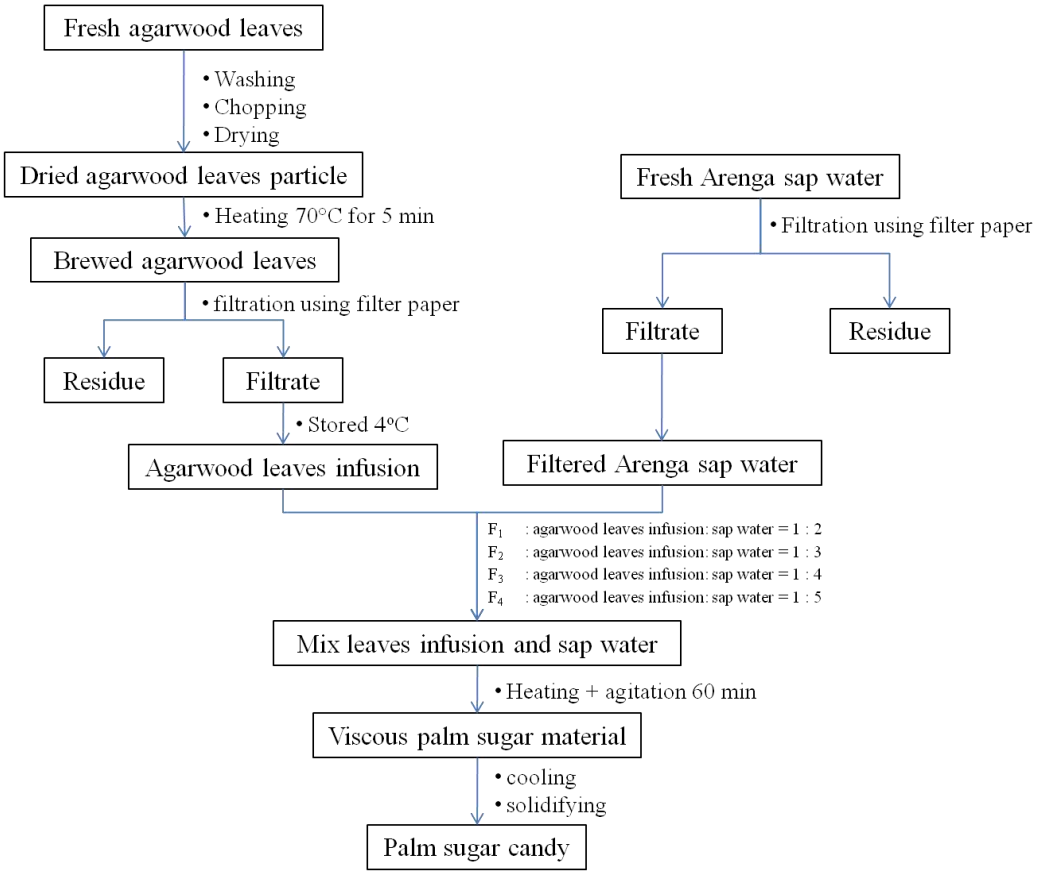

Figure 1. Stages of research

1. Research Material

Arenga pinata sap water was taken from Pemenang Village North Lombok, while agarwood (G. versteegii) leaves were taken from Kekait Village West Lombok. Compounds for protein, carbohydrate, and lipid analyses were used for proximate analysis including: K_2SO_4, $CuSO_4$, NaOH, H_3BO_3, and HCl. This research used several instruments, including an electric oven (Olike), electric furnace, Kjeldahl equipment, Soxhlet equipment (Pyrex), frying pan with agitation (RRC), grinding machine (Miyako), electric stove (Eastern Electric), analytical digital scale (Jadever) and modified silicon candy mould.

2. Agarwood leaves infusion production

Leaves from the agarwood tree sample were chosen based on their size (length 8 cm – 15 cm), shape (elliptic-oblong), and condition. Agarwood leaf infusion was made with leaves ranging from 5 cm to 15 cm, showing no necrosis or chlorosis (Triandini et al., 2022).

Agarwood leaves were washed three times with flowing water to remove dirt and dust. The leaves were then ground into small particles (1 mm – 2 mm in size) with a grinding machine. The particles of leaves were then dried in an oven at 120oC for two hours until water contains the remaining 10% (Wangiyana et al., 2019).

Agarwood leaf infusions are produced at a concentration of 0.02 gr per L. Agarwood leaf particles were extracted with distilled water at 70°C for 5 minutes. Filtration with qualitative filter paper was used to separate filtrate from residue. The filtrate from this method is an infusion of agarwood leaves, which was held at 4 degrees Celsius before being blended with Arenga pinata sap water to keep it fresh (Wangiyana et al., 2018).

Palm sugar candy mix agarwood leaves infusion

The primary treatments used in this research are formulations of agarwood leaf infusion and Arenga sap water. Sap water was previously filtered through qualitative filter paper (Kurniawan et al., 2018). Filtered sap water was mixed with agarwood leaves infusion in different proportions **(Table 1)**. Different proportions of agarwood leaves infusion and sap water are shown to examine different appearances, aromas, and tastes of palm sugar candy.

The mixture of agarwood leaves infusion, and sap water of each treatment were cocked in a frying pan with agitation for 60 minutes. The mixtures were heated until the volume was 8% of the initial volume and became viscous. Viscous palm sugar material is solidified 30oC in the silicone candy mould (Victor & Orsat, 2018).

Table 1.
Formulation of agarwood leaves infusion and Arenga sap water

Code	Treatment description
F_1	agarwood leaves infusion: sap water = 1: 2
F_2	agarwood leaves infusion: sap water = 1 : 3
F_3	agarwood leaves infusion: sap water = 1: 4
F_4	agarwood leaves infusion: sap water = 1:5

Proximate analysis

Proximate analysis is essential to support the hedonic test, making the consumer preference data more comprehensive. Palm sugar candy without adding agarwood leaves infusion was subjected to proximate assay. This assay aims to measure total water content, total ash content, total carbohydrate content, total protein content and total lipid content(Thangaraj, 2016).

Proximate analysis carried out according to the standard of INS 01-2891-1992. Total water content was measured using the thermogravimetric test. Total ash content was measured usingthe drying ash method by furnacecombustion. Total fat content measurement was carried out using the Soxhletation method. Total protein content measurement was conducted using the Kjehdahl method. Total carbohydrate content is estimated based on calculations (Eden & Rumambarsari, 2020):

$$\%C = 100\% - (\%P + \%L + \%A + \%W)$$

%C = Total Carbohydrate
% P = Total Protein
% L = Total Lipid
% A = Total Ash
%W = Total Water

Sensory Evaluation

Sensory evaluation in this research was conducted by using a 9-point hedonic scale. The hedonic scale in this research could be divided into verbal and numerical hedonic scales **(Table 2**). The verbal hedonic scale is the hedonic scale that directly expresses the preference level of the respondent. The numerical hedonic scale is the conversion of the verbal hedonic scale for statistical analysis purposes (Xia et al., 2021).

A total of 30 people with an age range from 20 - to 24 years old were chosen as respondents in this research. These are food sensory respondents from Universitas Pendidikan Mandalika who participated in 9-point hedonic scale training (Wangiyana et al., 2023). All respondents gave an evaluation in four parameters, including appearance, aroma, taste, and texture.

Table 2.
Verbal hedonic scale and numerical hedonic scale in this research

Verbal Hedonic Scale	Numerical Hedonic Scale
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Analysis Data

Descriptive and inductive statistical approaches were used for data analysis. The numerical hedonicscale of each treatment was analyzed using Descriptive analysis in the form of a spider web diagram. Inductive statistics is conducted using different statistical approaches, including the Kruskal-Wallis test, Freidman test, Analysis of Variance – Completely Randomized Design (ANOVA-CRD), and Analysis of Variance – Randomized Complete Block Design (ANOVA-RCBD) **(Table 3)**. Duncan Multiple Range Test (DMRT) a 0.05 was also conducted to examine the treatment effect on the numerical hedonic scale of each parameter. All data analyses were performed using co-stat for Windows(Wangiyana & Triandini, 2022).

Table 3.
Summary of statistical method approaches in this research

statistical Approach	Assumption	Linear model	Description
Kurskal-Wallis	Palm Sugar Candy and respondents are homogenous	$H = \frac{12}{N(N+1)}\sum_{i=1}\frac{R_i^2}{n_i} - 3(N+1)$	Ri = ranking in the column N = Total Number of Sample ni = Number of treatments
Freidman Test	Respondents are heterogeneous (become group)	$X^2 = \frac{12}{bt(t+1)}\sum r^2 - 3b(t+1)$	b = Number of Group t = Number of Treatments r = Number of ranking
ANOVA CRD	Normal distribution of numeric scale and respondents are homogenous	$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$	Y_{ij} = An observation μ = The Experimental Mean τ_i = The Treatments Effect ε_{ij} = The Experimental Error
ANOVA RCBD	Normal distribution of numeric scale and respondents are heterogeneous (become block)	$Y_{ij} = \mu + \tau_i + \beta_j + \varepsilon_{ij}$	Y_{ij} = An observation μ = The Experimental Mean τ_i = The Treatments Effect B_j = The Block Effect ε_{ij} = The Experimental Error

RESULTS AND DISCUSSION

Proximate analysis shows that the carbohydrate compound mostly dominated palm sugar candy (figure 2). Carbohydrates have a proportion of about 87% among all other compounds. Palm sugar candy's total protein and lipid content was only 3% and 1%, respectively. This result indicates that palm sugar candy, like other typical candy products contain, is high in carbohydrates, including sugar, which is the monomer of carbohydrates (Adeoye et al., 2019; Akhter et al., 2022; Sahlan et al., 2019).

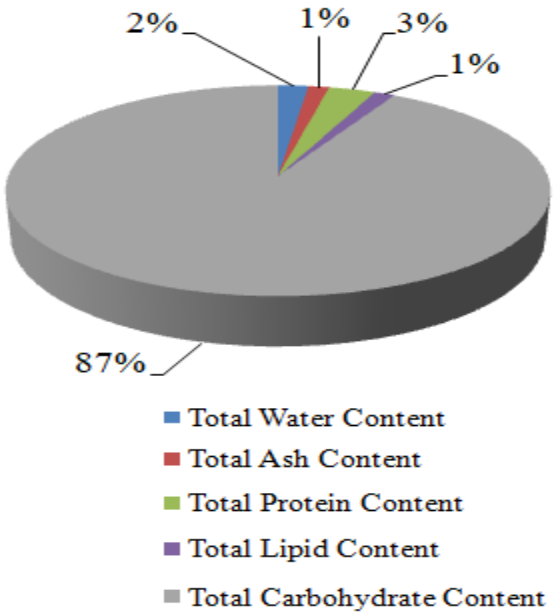

Figure 2. Proximate analysis result of palm sugar candy

The high total carbohydrate content in palm sugar candy indicates its potency as a culinary product that provides an instant energy resource. Commonly, culinary products with high-energy sources known as energy are made from various seeds(A. Verma et al., 2022) or cereals(Boukid et al., 2022). Palm sugar candy can be an alternative energy bar product that can be applied in sports or any exercise with high energy demands. However, palm sugar candy is not recommended for people with restricted carbohydrates on the dietary menu due to diabetes(Lennerz et al., 2021) or obesity(Gjuladin-Hellon et al., 2019).

A different statistical approach was used to analyze the effect of treatment on the numerical hedonic scale **(Table 4)**. The treatment effect's significant impact was described as a P-value(Shrestha, 2019).The lower the P-value of the numerical hedonic scale, the higher the significant level of the impact(Andrade, 2019). Most parameters have p-values, which shows that the treatment effect

was highly significant. This shows the high degree of validity of the treatment effect on the numerical hedonic scale. However, aroma parameters have some non-significant p-values when analyzed using Kruskal-Wallis and ANOVA-CRD.

Kruskal Wallis is a non-parametric statistical approach, while ANOVA-CRD is a parametricone. However, both statistical approaches assumed that respondents' evaluations were homogenous (J. P. Verma & Abdel-Salam, 2019). This result indicates that respondents in this research were not giving homogenous numerical hedonic scales, which affected the normal distribution of the data. Forming a block or group assuming respondents are heterogeneous can reduce the effect of the non-normal distribution of the numerical hedonic scale given by the respondents in the aroma parameter. This is shown by the significant and very highly significant p-values in ANOVA-RCBD and Friedman-Test, respectively.

Table 4.
Comparison of P-value using different statistical approaches

Statistical Approach	Parameter	P Value
Kruskal-Wallis	Appearance	0.00001 ***
	Aroma	0.1523 ns
	Taste	0.00001 ***
	Texture	0.00001 ***
Friedman Test	Appearance	0.00001 ***
	Aroma	0.00001 ***
	Taste	0.00001 ***
	Texture	0.00001 ***
ANOVA-CRD	Appearance	0.00001 ***
	Aroma	0.1012 ns
	Taste	0.00001 ***
	Texture	0.00001 ***
ANOVA-RCBD	Appearance	0.00001 ***
	Aroma	0.0471 *
	Taste	0.00001 ***
	Texture	0.00001 ***

Note: ns = non-significant (P value is more than 0.05), * = significant (P value is 0.01 – 0.05), ** = highly significant (P value is 0.001 – 0.01), *** very highly significant (P value is less than 0.001)

Table 5.
DMRT analysis of average numerical hedonic scale in different parameter

Treatment	Average Numerical Hedonic Scale ± Error Value				
	Appearance	**Aroma**	**Taste**	**Texture**	**Overall**
F_1	6.13 ± 0.29 (b)	6.33 ± 0.28 (b)	5.30 ± 0.36 (c)	6.07 ± 0.31 (b)	5.96 ± 0.16 (b)
F_2	6.17 ± 0.24 (b)	6.43 ± 0.26 (b)	5.37 ± 0.37 (c)	5.43 ± 0.31 (b)	5.85 ± 0.15 (b)
F_3	6.70 ± 0.24 (b)	7.07 ± 0.17 (a)	8.13 ± 0.10 (a)	5.37 ± 0.34 (b)	6.82 ± 0.15 (a)
F_4	7.77 ± 0.18 (a)	6.33 ± 0.26 (b)	6.60 ± 0.36 b)	7.33 ± 0.21 (a)	7.01 ± 0.14 (a)
	LSD 0.05 = 0.62	LSD 0.05 = 0.59	LSD 0.05 = 0.85	LSD 0.05 = 0.84	LSD 0.05 = 0.41

Note: Different mean values followed by the same letters differ significantly ($p<0.05$). F_1 = agarwood leaves infusion : sap water = 1 : 2, F_2 = agarwood leaves infusion : sap water = 1 : 3, F_3 = agarwood leaves infusion : sap water = 1 : 4, F_4 = agarwood leaves infusion : sap water = 1 :5

Duncan Multiple Range Test (DMRT) results show a significant difference in the average numerical hedonic scale between treatments. This analysis has an excellent sensitivity to differentiate range scale tests like hedonic scores (Lee & Lee, 2018). The different parameters have the highest numerical hedonic scales, dominated by F_3 and F_4 treatments. F3 have the highest average numerical hedonic scale in aroma and taste, while F4 have the highestaverage in appearance and texture. Based on the overall analysis of all parameters, the numerical hedonic scale of F4 is slightly higher than F3. However, that value is not significantly different based on DMRT analysis.

A comparison between respondents' evaluation of F3 and F4 treatment can be analyzed more clearly using a spider chart (Kayali et al., 2023). The chart shows that F4 treatment has an advantage in appearance and texture parameters while F3 has an advantage in aroma and taste parameters (figure 3). However, the area of F4 is slightly larger than that of F3. This spider chart also confirms respondents' low numerical hedonic scores in F1 and F2 treatments.

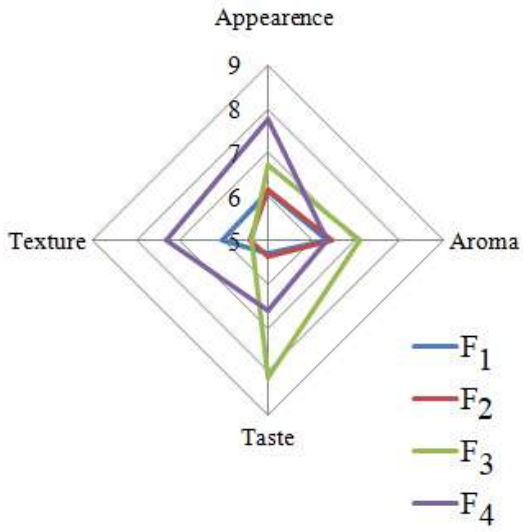

Figure 3. Spider web analysis of numerical hedonic scale in each parameter (F1 = agarwood leaves infusion: sap water = 1: 2, F2 = agarwood leaves infusion: sap water = 1 : 3, F3 = agarwood leaves infusion: sap water = 1: 4, F4 = agarwood leaves infusion: sap water = 1:5)

Since the numerical hedonic scores of F3 and F4 are not significantly different, verbal hedonic scores can be used as additional evaluation to determine which is better between those treatments. This data is related to previous research, which states that verbal hedonic scores correlate to numerical hedonic scores and could support each other (Xia et al., 2015). The number of respondents who give like very much and extremely to F4 is higher than those of F3 **(Figure 4)**. Unlike the numerical hedonic scale, which can be mathematically calculated, the verbal hedonic scale is a qualitative scoring that directly shows respondents' preferences (Xia et al., 2021). Thus, it can be indicated that respondents prefer F4 over F3.

Based on the numerical and verbal hedonic scores, F4 treatment can be considered the best formulation of agarwood leaves infusion and sap water. Proximate analysis confirms the hedonic test that the respondent prefers palm sugar candy due to its high carbohydrate content. F4 is the formulation with the most minor agarwood leaf infusion content. Thus, it only needs a small amount of agarwood leaves infusion to produce palm sugar candy, which the respondents have liked.

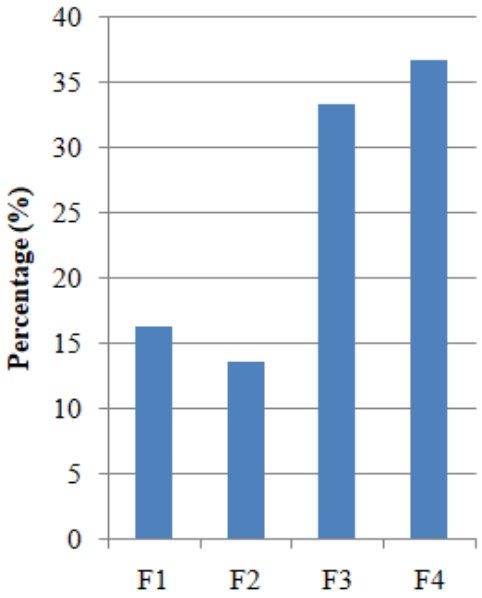

Figure 4. Proportion (percentage) of respondents who give like very much and extremely

CONCLUSION

It could be concluded that a mixture of agarwood leaves infusion and Arenga sap water with a proportion 1 of 5 was the best formulation to produce palm sugar candy with the highest sensory evaluation score based on a 9-point hedonic scale. Further research about nutritional adequacy rate can be conducted based on proximate assay and hedonic test data. This research is essential to support the commercialization of palm sugar candy products.

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