Indonesian Journal of Applied Research IJAR

PECTIN EXTRACTION FROM AMBON BANANA (*Musa paradisiaca var. sapientum*) PEEL AND ITS APPLICATION FOR GUMMY JELLY

Volume 4 Issue 1
(April 2023)
e-ISSN 2722-6395
doi: 10.30997/ijar.v4i1.243

Muhammad Fakih Kurniawan[1], Distya Riski Hapsari[1], R. Siti Nurlaela[1], Nuraimy Citra[1]

[1]*Food Technology and Nutrition, Universitas Djuanda*

ARTICLE INFO

Article history:
Received: 14-11-2022
Revised version received: 04-12-2022
Accepted: 01-04-2023
Available online: 18-04-2023

Keywords:
ambon banana; banana peel pectin; carrageenan; gummy jelly; pectin

How to Cite:
Kurniawan, M. F., Hapsari, D. R., Nurlaela, R. S., & Citra, N. (2023). PECTIN EXTRACTION FROM AMBON BANANA (Musa paradisiaca var. sapientum) PEEL AND ITS APPLICATION FOR GUMMY JELLY. *Indonesian Journal of Applied Research (IJAR)*, *4*(1), 75-83. https://doi.org/10.30997/ijar.v4i1.243

Corresponding Author:
Muhammad Fakih Kurniawan
fakih.kurniawan@unida.ac.id

ABSTRACT

Considered a waste, the peel of the Ambon banana (*Musa paradisiaca var. sapientum*) contains an appreciable amount of pectin. Pectin can be used to produce gummy jelly products with the addition of carrageenan as a stabilizer. The manufacture of gummy jelly must consider a good proportion of pectin and carrageenan. This study aimed to extract pectin from Ambon banana peel and determine the best formulation of gummy jelly incorporated with the pectin and carrageen as a gelling agent. Pectin was extracted from Ambon banana peel and then analyzed for yield, ash content, equivalent weight, methoxyl content, galacturonic content, and degree of esterification. Gummy jelly was made with various levels of pectin (0.5%, 1%, 1.5%, 2%) and carrageenan (1%, 1.5%, 2%). The product was analyzed for water content, ash content, reducing sugar content, sensory quality test, and hedonic test. The characteristics of pectin, i.e., moisture content, ash content, galacturonic acid content, methoxyl content, and the degree of esterification, were compared to IPPA (International Pectin Producer Association) standard. Meanwhile, the gummy jelly samples were confirmed to comply with the requirements of SNI Soft Candy 3547-2-2008 for water content, ash content, and reduced sugar content. In addition, we found that a higher concentration of pectin in the formulation led to a lower chewiness, decreasing the panelist's preference. Considering the chemical and sensory properties of the candy, the most desirable formulation was achieved at the ratio of pectin and carrageenan 1.5%:2%. Pectin from banana peels can be used as an ingredient in gummy jelly. This work suggested further studies on the candy's textural properties, such as gumminess and chewiness.

1. INTRODUCTION

Indonesia produces a large banana production of 7,162 675 tons, which accounts for the third largest banana producer globally after China and India (FAO, 2019). The massive amount of fruit also remains a significant challenge regarding its waste, i.e., banana peel, which must be utilized more. On the other hand, the peel is rich in nutritious and incredible constituents such as pectin, carbohydrates, fat, protein, calcium, phosphorus, iron, vitamin B, vitamin C, and water (Padam et al., 2014). Among these chemicals, pectin can be the most prospective. It is a hetero-polysaccharide existing in the primary cell walls of plants. It is a high-value functional food because of its excellent emulsifying properties and stability, making it a flawless ingredient as a gelling agent and stabilizer in food products (Khamsucharit et al., 2018). As reported by (Tuhuloula et al., 2013), pectin in Ambon banana peel reached 14.98%, extracted by using HCl for 2 hours. The extracted pectin was characterized as white to brown powder (Nurhayati et al., 2016).

Pectin isolated from banana peel extract can be used as a gelling agent, forming a good gel in a tomato-based jam with 1% pectin (Sucitra et al., 2018). Pectin is also a key ingredient in jelly candy (Soedirga & Marchellin, 2022). In the manufacture of gummy jelly, there are three conditions for gel formation, including pectin, sugar, and acid (Gawkowska et al., 2018). Pectin enables intensive gel production with sugar, acid, and stabilizer; hence, water is trapped and agglomerated to form fine fibers that can hold liquids at a low pH condition (Sucitra et al., 2018). According to Nuh et al. (2020), the desirable chewy texture of the gummy jelly was obtained with the combination of pectin and stabilizer.

Carrageenan is a powdered ingredient isolated from seaweed, especially Rhodophyceae, which commonly functions as an emulsifier, stabilizer, thickener, and gelling agent (Sormin et al., 2019). According to Thommes et al. (2009), carrageenan was the most satisfying water binder, despite being added at low concentration, and can convert polysaccharides into gel-like materials. However, when pectin and carrageenan were added excessively, they may reduce the elasticity of gummy jelly; conversely, at too low a concentration, the gel was not formed (Parnato et al., 2016). Therefore, the manufacture of gummy jelly must consider a good proportion of pectin and carrageenan. In this work, pectin was isolated from Ambon banana peel, then the chemical and sensory properties of the formulated candy were evaluated.

2. METHODS

The research method has two stages: extracting pectin from banana peel flour and preparing gummy jelly with a combination of pectin and carrageenan. Ambon banana peels were obtained from banana cake shop waste in Cibinong, Bogor, Indonesia. This study used a Complete Randomized Design (RAL) with two factors, namely, the first factor is pectin (A) which consists of 4 levels (0.5%, 1.0%, 1.5%, 2%, and the second factor is carrageenan (B) which consists of 3 levels (1%, 1.5%, 2%). Each treatment was carried out in two times of replications. The model for a completely randomized design used in this research was :

$$Yijk = \mu + \alpha i + \beta j + (\alpha\beta)ij + \varepsilon ijk$$

Yijk: The results of observations from the factor of addition pectin level to-i, factor addition carrageen level to-j, and repetition to-k
μ: the general location parameter
αi: The main effect of the addition of pectin to i
βj: The main effect of the addition of carrageenan to-j
(αβ)ij: The interaction component of the effect of the addition pectin level to-i, factor addition carrageenan level to-j to gummy jelly

εij: random error
i: The number of treatment levels of factor A(1,2,3,4)
j: The number of treatment levels of factor B (1,2,3,4)
k: number of replication (1,2,3)

2.1. Preparation of banana flour

The Banana peel was oven-dried at 80°C for 12 hours. The dried peel was pulverized using an electric blender and sieved at 80-mesh siever (Randa et al., 2021).

2.2. Extraction of pectin from banana peel flour

Banana peel flour (30 g) was added with solvent 1 L of HCl 0.05 N, then heated on a hotplate at 80°C for 2 hours. The solution was filtered using a Buchner funnel to collect the filtrate. Subsequently, the filtrate was added with 96% (1:1) ethanol under constant stirring until a precipitate was formed. The precipitate was separated using a Buchner funnel and purified using ethanol until no reaction between ethanol and acid was checked using a phenolphthalein indicator. The precipitate was oven-dried at 37-45°C for 6-10 hours. The drying was stopped when it reached a constant weight; then, the yield was recorded (Tuhuloula et al., 2013). Then the yield of pectin is calculated using the formula below.

$$\% \text{ yield} = \frac{weight\ of\ pectin}{weight\ of\ banana\ flour} \text{x } 100\%$$

2.3. Preparation of gummy jelly

Water, sorbitol (16 g), and high fructose sweetener (50 g) were mixed thoroughly on the stove at 98 °C. Carrageenan (1%, 1.5%, 2%) and pectin (0.5%, 1%, 1.5%, 2%) were added to the mixture using an experimental formulation and heated at 100 °C under constant stirring until it formed a consistent mixture. The heating temperature was maintained for 5 minutes, then lowered to 40 °C. Food colorant, orange flavor, and 0.2g citric acid were added, followed by a stable stirring. The hot mixture of gummy jelly was transferred into a special mold and cooled to room temperature, leaving it hardened gradually (Isnanda et al., 2016).

2.4. Pectin and gummy jelly analysis

Characteristics of pectin were evaluated as follows: pectin yield, moisture content (AOAC, 2005), ash content (AOAC, 2005), equivalent weight (Kanmani, 2014), methoxyl content (Kanmani, 2014), galacturonate content (Kanmani, 2014), and degree of esterification (Kanmani, 2014). Meanwhile, the gummy jelly analyses included water content (AOAC, 2005), ash content (AOAC, 2005), reducing sugar content (AOAC, 2005), sensory quality test (Setyaningsih et al., 2010), and hedonic test (Setyaningsih et al., 2010). Sensory quality and hedonic tests were conducted with 30 semi-trained panelists using a 0-10 cm line scale. Color parameters have a description of 0 (dark orange) – 10 (bright orange), texture 0 (very not chewy) – 10 (very chewy), and hedonic 0 (dislike very much) – 10 (like very much)

2.5. Statistical Analysis

Each treatment was carried out in two times of replications and statistically tested for chemical Analysis according to one-way ANOVA using SPSS version 25. Duncan's test at a significance of 5% was performed to compare significant means. The organoleptic test data were analyzed using the Kruskal Wallis non-parametric test. If an effect of treatment on the organoleptic properties of gummy jelly had been found, a Mann-Whitney follow-up test was carried out.

3. RESULTS AND DISCUSSION

3.1. Characteristics of Ambon Banana Peel Pectin

The yield of pectin from Ambon banana peel was 11.86%. This value is lower than the research of Tuhuloula et al. (2013), which found the yield of Ambon banana peel pectin was 14.89%. Furthermore, the pectin was chemically tested and compared with the International Pectin Producers Association (IPPA) standard (IPPA, 2014)

Table 1 Properties of banana pectin samples compared with IPPA Standard

Parameters	Standard	Result
Moisture content	Max. 12%	10,59%
Ash content	Max. 10%	6,20%
Galacturonic acid content	Min 35%	68,65%
Methoxyl content	High methoxyl >7,12% Low methoxyl 2,5–7,12%	4,13% (low)
Equivalent weight	600 – 800 mg	7178,57 mg
Degree of esterification	High pectin ester min 50% Low pectin ester max 50%	22,62% (low)

As presented in Table 1, the results indicated that most parameters of banana peel pectin were appropriate to IPPA standard, including water content 10.59%, ash content 6.20%, galacturonic acid 68.65%. This galacturonic acid is higher than the research of Mahardiani et al. (2021) (41,18%). Furthermore, methoxyl content in pectin was recorded as a low category, reaching 4.13%. A similar result was also found in the degree of esterification, reaching 22.62%, which was categorized as low. The equivalent weight of the pectin reached 7178.57 mg, indicating that it was not appropriate to the IPPA standard. The equivalent weight may differ significantly depending on the plant source, raw material quality, extraction method, and extraction process (Muthukumaran et al., 2017). The most influential factor contributing to equivalent weight is the nature of the extracted pectin and titration process (Siddiqui et al., 2021). If the equivalent weight may be more significant, it reflects the achievement of a higher gel-forming ability (Wongkaew et al., 2020).

3.2. Gummy jelly chemical characteristics

3.2.1. *Moisture Content*

The results showed that moisture content ranged from 12.36 to 15.96%, suggesting that it conformed to SNI soft candy 3547-2-2008 (not greater than 20%), as seen in Table 2. The higher proportion of pectin and carrageenan decreased water content. This displays the water-binding capacity of pectin, which facilitates the formation of denser fine fiber and compact gel, thereby decreasing the amount of free water (Sucitra et al., 2018). Moreover, the greater level of carrageenan raised the number of solids in the food matrix, thus declining water content. It is noteworthy that carrageenan can play as an emulsifier, thickener, and stabilizer, enabling retaining the stability of a homogeneous dispersion system and increasing the total dissolved solids, reducing the water content (Thommes et al., 2009). Pectin and carrageenan are gelling agents. The gel-forming material is a phenomenon or cross-linking of polymer chains to form a continuous three-dimensional mesh. Furthermore, this net can capture or immobilize water to form a strong and rigid structure (Alves et al., 2011). Thus, the more pectin and carrageenan concentrations added, the lower the water content of the gummy jelly produced.

Table 2 Moisture content (%) of Gummy Jelly Incorporated with Ambon Banana Peel Pectin and Carrageenan

Pectin	Carrageenan		
	B1 (1%)	B2 (1,5%)	B3 (2%)
A1 (0,5%)	15,96±1,1^{c}	15,20±0,93^{c}	14,16±0,59^{abc}
A2 (1%)	14,98±0,93^{bc}	14,30±0,6^{abc}	13,03±0,63^{ab}
A3 (1,5%)	14,17±0,66^{abc}	13,05±0,85^{ab}	12,79±0,74^{a}
A4 (2%)	13,07±1,03^{ab}	12,65±0,73^{a}	12,36±0,65^{a}

Note: different superscripts in similar columns show a significant difference at $\alpha = 0,05$; A = pectin and B = carrageenan.; All values in the table are the mean (mean) ± standard deviation

3.2.2. *Ash Content*

Table 3 demonstrated the ash content of samples, ranging from 1.07 to 2.17%, meaning that all samples complied with SNI soft candy 3547-2-2008 (ash content not greater than 3%). The rise of pectin in candy formulation resulted in a higher ash level. This may display the ability of pectin to bind more minerals from water and dissolved solids, thereby increasing the ash content (Khotimchenko et al., 2012). Moreover, carrageenan isolated from seaweed is also rich in minerals, contributing to the rise of minerals in samples (Sormin et al., 2019).

Table 3 Ash content (%) of Gummy Jelly Incorporated with Ambon Banana Peel Pectin and Carrageenan

Pectin	Carrageenan		
	B1 (1%)	B2 (1,5%)	B3 (2%)
A1 (0,5%)	1,07±0,09^{a}	1,32±0,06^{b}	1,57±0,04^{bcde}
A2 (1%)	1,34±0,09^{bc}	1,51±0,07^{bcd}	1,77±0,08^{efg}
A3 (1,5%)	1,58±0,08^{cde}	1,74±0,04^{def}	1,98±0,08^{fgh}
A4 (2%)	1,81±0,06^{efg}	2,01±0,14^{gh}	2,17±0,04^{h}

Note: Different superscripts in similar columns show a significant difference at $\alpha = 0,05$; A = pectin and B = carrageenan.; All values in the table are the mean (mean) ± standard deviation

3.2.3. *Reducing Sugar Content*

As presented in Table 4, the reduced sugar content in samples ranged from 14.35 to 18.04%, also in line with SNI soft candy 3547-2-2008 (reducing sugar content not greater than 25%). The results revealed that reduced sugar content increased as more carrageenan was added. It is noted that the carbohydrate content in carrageenan is higher than that in pectin. Meanwhile, the rise of carrageenan proportion led to increased reducing groups, reducing sugar content (Winarno, 2008).

Table 4 Reducing Sugar Content (%) of Gummy Jelly Incorporated with Ambon Banana Peel Pectin and Carrageenan

Pectin	Carrageenan		
	B1 (1%)	B2 (1,5%)	B3 (2%)
A1 (0,5%)	14,35±0,47^{a}	14,95±0,86^{a}	15,97±0,75^{ab}
A2 (1%)	14,90±0,90^{a}	15,89±0,73^{ab}	17,11±0,14^{ab}
A3 (1,5%)	14,94±0,88^{a}	15,93±0,84^{ab}	16,97±0,79^{ab}
A4 (2%)	15,39±1,27^{ab}	17,06±0,12^{ab}	18,04±0,08^{b}

Note: Different superscripts in similar columns show a significant difference at $\alpha = 0,05$; A = pectin and B = carrageenan.; All values in the table are the mean (mean) ± standard deviation

3.3. Gummy Jelly Sensory Characteristics

3.3.1. *Color*

Table 5 Color Score Of Gummy Jelly Incorporated With Ambon Banana Peel Pectin And Carrageenan

Pectin	Carrageenan		
	B1 (1%)	B2 (2)	B3 (3)
A1 (0,5%)	7,05±0,56^{ab}	7,35±0,45^{ab}	7,40±0,36^{ab}
A2 (1%)	7,55±0,14^{b}	7,40±0,10^{ab}	6,55±0,06^{a}
A3 (1,5%)	7,25±0,19^{ab}	7,35±0,14^{ab}	7,40±0,19^{ab}
A4 (2%)	7,05±0,07^{ab}	6,75±0,16^{ab}	7,10±0,20^{ab}

Note: Different superscripts in similar columns show a significant difference at $\alpha = 0,05$; A = pectin and B = carrageenan.; All values in the table are the mean (mean) ± standard deviation

Table 5 presents the results of the sensory assessment for samples. In this work, we reported that pectin concentration and the interaction of pectin and carrageenan showed no significant effects on the color attribute, ranging from 6.55 – 7.55. This can be explained by the fact that both ingredients are colorless. Thus they unalter the sample's color. The color score indicated that the sample appearance was bright orange.

3.3.2. *Texture*

Table 6 Texture Score Of Gummy Jelly Incorporated With Ambon Banana Peel Pectin And Carrageenan

Pectin	carrageenan		
	B1 (1%)	B2 (1,5%)	B3 (2%)
A1 (0,5%)	4,65±0,49^{b}	5,85±0,12^{cd}	6,35±0,06^{de}
A2 (1%)	4,80±0,38^{b}	5,40±0,09^{bc}	6,40±0,18^{de}
A3 (1,5%)	5,20±0,43^{bc}	6,35±0,04^{de}	6,85±0,03^{d}
A4 (2%)	2,55±0,14^{a}	3,30±0,26^{a}	5,65±0,02^{cd}

Note: Different superscripts in similar columns show a significant difference at $\alpha = 0,05$; A = pectin and B = carrageenan.; All values in the table are the mean (mean) ± standard deviation

Regarding texture, the score ranged from 2.55 – 6.85, suggesting that all samples are highly chewy (Table 6). The samples were perceived as less chewy in samples containing a higher percentage of pectin than carrageenan. However, the proportion of carrageenan surpassing pectin led to a firm texture of gummy jelly. Carrageenan can produce a more muscular gel strength than pectin (Saha & Bhattacharya, 2010). Pectin shows a low water binding ability compared to carrageenan; hence, adding pectin at 2 g would make brittle and soft (not sturdy) candy but produce a good gel at low pH (Thommes et al., 2009).

3.3.3. *Overall Hedonic Test*

Table 7 Overall Hedonic Test Of Gummy Jelly Incorporated With Ambon Banana Peel Pectin And Carrageenan

Pectin	Carrageenan		
	B1 (1%)	B2 (1,5%)	B3 (2%)
A1 (0,5%)	$5.95\pm0,05^{c}$	$6,15\pm0,02^{cd}$	$6,55\pm0,06^{f}$
A2 (1%)	$6.30\pm0,08^{def}$	$6,40\pm0,08^{ef}$	$6,50\pm0,11^{f}$
A3 (1,5%)	$5.65\pm0,07^{b}$	$6,10\pm0,10^{cd}$	$7,00\pm0,07^{g}$
A4 (2%)	$4.90\pm0,1^{a}$	$5,05\pm0,15^{b}$	$6,05\pm0,03^{cd}$

Note: Different superscripts in similar columns show a significant difference at $\alpha = 0,05$; A = pectin and B = carrageenan.; All values in the table are the mean (mean) ± standard deviation

As presented in Table 7, the rise of pectin proportion leads to a decrease in the overall hedonic score. When more pectin was added to the formula, the texture of the samples was less chewy. However, data revealed that most samples were scored above 5, indicating the liking degree given by panelists. In this study, the most appreciable proportion of pectin and carrageenan was found at 1.5% and 2%, respectively, considering the chemical and sensory properties of the samples. The formulation could produce gummy jelly that conforms to the above standard regarding water content, ash, and reducing sugar and shows the highest color and preference by panelists.

4. CONCLUSION

This current work presented pectin quality extracted from Ambon banana peel, which was pertinent to the IPPA standard for moisture content, ash content, galacturonic acid content, methoxyl content, and degree of esterification. At the same time, the equivalent weight was found to surpass the threshold. Some chemical properties of gummy jelly samples, i.e., water content, ash content, and reducing sugar content, complied with the requirement of SNI Soft Candy 3547-2-2008. We also found that pectin and carrageenan showed no significant effects on color, but they markedly affected texture and preferences assessed by panelists. The lower chewiness was obtained when more pectin was added, which led to a decrease in the panelist's preference. The best formulation was acquired at the proportion of pectin 1.5% and carrageenan 2%. The following research needs to test the gumminess and chewiness of gummy jelly and analyze the sensory attribute profile.

ACKNOWLEDGMENT

Authors expressed a sincere gratitude to the Center for Research and Community Service, Universitas Djuanda, Bogor, for funding this research through a scheme of Hibah Dana Internal Perguruan Tinggi Universitas Djuanda Bogor 2022 Number 1052/01/K-X/IX/2022

REFERENCES

AOAC. (2005). *Official Methods of Analysis of AOAC International 18th edition*. AOAC International.

Alves, V., D., Castello, R., Ferreira, A., R., Costa, N., Fonseca I., M., & Coelhosa I., M. (2011). Barrier properties of carrageenan/pectin biodegradable composite films. *Procedia Food Science 1*: 240 – 245. doi:10.1016/j.profoo.2011.09.038

FAO. (2019). *Top 10 Country Production of Bananas*. Retrieved August 5, from https://www.fao.org/markets-and-trade/commodities/bananas/en/

Gawkowska, D., Cybulska, J., & Zdunek, A. (2018). Structure-Related Gelling of Pectins and Linking with Other Natural Compounds: A Review. *Polymers*, *10*(7), 762. https://doi.org/10.3390/polym10070762

International Pectin Producers Association (IPPA). (2014). *Pectin commercial production and pectin in organic food products*. Retrieved August 5, from https://pectinproducers.com

Isnanda, D., Novita, M., & Rohaya, S. (2016). Pengaruh Konsentrasi Pektin dan Karagenan terhadap Permen Jelly Nanas (Ananas comosus L. Merr). *Jurnal Ilmiah Mahasiswa Pertanian*, *1*(1), 912–923. https://doi.org/10.17969/jimfp.v1i1.1114

Kanmani, P. (2014). Extraction and Analysis of Pectin from Citrus Peels: Augmenting the Yield from Citrus limon Using Statistical Experimental Design. *Iranica Journal of Energy and Environment*, *5*(3). https://doi.org/10.5829/idosi.ijee.2014.05.03.10

Khamsucharit, P., Laohaphatanalert, K., Gavinlertvatana, P., Sriroth, K., & Sangseethong, K. (2018). Characterization of pectin extracted from banana peels of different varieties. *Food Science and Biotechnology*, *27*(3), 623–629. https://doi.org/10.1007/s10068-017-0302-0

Khotimchenko, Y., Khozhaenko, E., Kovalev, V., & Khotimchenko, M. (2012). Cerium binding activity of pectins isolated from the *Seagrasses zostera* marina and *Phyllospadix iwatensis*. *Marine Drugs*, *10*(12), 834–848. https://doi.org/10.3390/md10040834

Mahardiani, L., Larasati, R., Susilowati, E., Hastuti , B., & Azizah, N.,L. (2021). Potential edible oating of pectin obtained from banana peel for fruit preservation. *Journal of Physics : Conference Series, 19*(12): 12-19 doi:10.1088/1742-6596/1912/1/012019

Muthukumaran, C., Banupriya, L., Harinee, S., Sivaranjani, S., Sharmila, G., Rajasekar, V., & Kumar, N. , M. (2017). Pectin from muskmelon (Cucumis melo var. reticulatus) peels: extraction optimization and physicochemical properties. *3 Biotech*, *7*(1), 66. https://doi.org/10.1007/s13205-017-0655-3

Nuh, M., Barus, W. , B. , J., Miranti, F. , Y., & Pane, M. , R. (2020). Studi pembuatan permen jelly dari sari buah nangka. *Wahana Inovasi*, *9*(1), 193–198.

Nurhayati, N., Maryanto, M., & Tafrikhah, R. (2016). Ekstraksi pektin dari kulit dan tandan pisang dengan variasi suhu dan metode. *Jurnal Agritech*, *36*(03), 327. https://doi.org/10.22146/agritech.16605

Padam, B. , S., Tin, H. , S., Chye, F. , Y., & Abdullah, M. , I. (2014). Banana by-products: an under-utilized renewable food biomass with great potential. *Journal of Food Science and Technology*, *51*(12), 3527–3545. https://doi.org/10.1007/s13197-012-0861-2

Parnato, N. , H. , R., Nurhartadi, E., & Rohmah, L. , N. (2016). Karakteristik fisik, kimia dan sensori permen jelly sari pepaya (Carica papaya L.) dengan konsentrasi karagenan-konjak sebagai gelly agent. *Jurnal Teknosains Pangan*, *51*, 19–27.

Randa, A., Hermawati, & Tang, M. (2021). Ekstraksi pektin dari kulit pisang kepok (Musa paradisiaca L) dan diaplikasikan pada selai tomat (Solanum lycopersicum). *SAINTIS*, *2*(1), 34–41.

Saha, D., & Bhattacharya, S. (2010). Hydrocolloids as thickening and gelling agents in food: a critical review. *Journal of Food Science and Technology*, *47*(6), 587–597. https://doi.org/10.1007/s13197-010-0162-6

Setyaningsih, Apriyantono, & Sari. (2010). *Analisis Sensori untuk Industri Pangan dan Agro*. IPB Press.

Siddiqui, A., Chand, K., & Shahi, N. C. (2021). Effect of Process Parameters on Extraction of Pectin from Sweet Lime Peels. *Journal of The Institution of Engineers (India): Series A*, *102*(2), 469–478. https://doi.org/10.1007/s40030-021-00514-3

Soedirga, L. , C., & Marchellin. (2022). Physicochemical properties of jelly candy made with pectin from red dragon fruit peel in combination with carrageenan. *Caraka Tani: Journal of Sustainable Agriculture*, *37*(1), 1–14. https://doi.org/10.20961/carakatani.v37i1.53798

Sormin, R. , B. , D., Masela, A., & Idris. (2019). Physicochemical properties of carrageenan originated from Lermatang Village, Southwest Maluku District. *IOP Conference Series: Earth and Environmental Science*, *339*(1), 012053. https://doi.org/10.1088/1755-1315/339/1/012053

Sucitra, Sukainah, A., & Mustarin, A. (2018). Pengaplikasian ekstrak pektin kulit pisang raja (Musa sapientum L) dan kulit pisang kepok (Musaparadisiaca L) pada selai tomat (Solanum lycopersicum). *Jurnal Pendidikan Teknologi Pertanian*, *4*(2), 50–63. https://doi.org/10.26858/jptp.v4i2.6612

Thommes, M., Ely, D. R., & Kleinebudde, P. (2009). The water binding behavior of κ-Carrageenan determined by three different methods. *Pharmaceutical Development and Technology*, *14*(3), 249–258. https://doi.org/10.1080/10837450802572359

Tuhuloula, A., Budiyarti, L., & Fitriani, E. , N. (2013). Karakteristik pektin dengan memanfaatkan limbah kulit pisang menggunakan metode ekstraksi. *Konversi*, *2*(1), 21–27. http://dx.doi.org/10.20527/k.v2i1.123

Winarno, F. G. (2008). *Kimia Pangan dan Gizi*. M-Brio Press, Bogor

Wongkaew, M., Sommano, S. , R., Tangpao, T., Rachtanapun, P., & Jantanasakulwong, K. (2020). Mango Peel Pectin by Microwave-Assisted Extraction and Its Use as Fat Replacement in Dried Chinese Sausage. *Foods*, *9*(4), 450. https://doi.org/10.3390/foods9040450