JPPIPA 11(9) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Improving Waffle Quality through Substitution of Dragon Fruit Peel Flour

Anita Wulandari[1], Amelia Nirmalawaty[1*]

[1] Department of Agroindustri, Faculty Vocation, University of 17 Agustus 1945 Surabaya, Surabaya, Indonesia.

Received: June 12, 2025
Revised: September 03, 2025
Accepted: September 25, 2025
Published: September 30, 2025

Corresponding Author:
Amelia Nirmalawaty
amelia@untag-sby.ac.id

DOI: 10.29303/jppipa.v11i9.12126

Abstract: Since 2019, the price of dragon fruit has often plummeted during peak harvest periods, causing farmers to delay harvesting or even discard the fruit into rivers. Various studies have been conducted to optimize the utilization of its bioactive compounds, such as proteins, fats, organic acids, and minerals, to address this issue. One such approach is utilizing dragon fruit peel as flour. This study aims to determine the optimal substitution percentage of dragon fruit peel flour (TKBN) in waffles to improve their quality through De Garmo's effectiveness test. Four levels of wheat flour substitution with dragon fruit peel flour were applied: 0% (P0), 3% (P1), 6% (P2), and 9% (P3), each replicated four times. The results showed that increasing the substitution of dragon fruit peel flour decreased the moisture and fat content in waffles, while protein, fiber, ash, and carbohydrate content increased. All organoleptic variables declined as the substitution level increased. It was concluded that a 6% substitution of dragon fruit peel flour significantly increased fiber, protein, carbohydrate, and ash content while reducing fat content, although the fat reduction was not statistically significant.

Keywords: Dragon fruit peel flour; de Garmo; Quality improvement; Waffles

Introduction

Agricultural waste worldwide is estimated at 2 billion tonnes per year (Singh et al., 2021). While in Indonesia agricultural waste production reaches 51.546 million tonnes of dry matter per year consisting of rice straw, corn, soybean, peanut and sweet potato straw (Fitriansyah, 2024). Agricultural waste in Indonesia is generally burned directly and then the ashes are sprinkled on local agricultural land or used as animal feed (Fitriansyah, 2024), but data on agricultural waste from vegetables and fruits has not yet been recorded.

In Indonesia, agricultural waste does not only come from crop residues, but can also come from fruits or vegetables that are deliberately not harvested by farmers during the peak harvest period when the price of agricultural commodities is falling (Abidin, 2025). Since 2019, one of the agricultural commodities that often drops in price during the peak harvest period is dragon fruit, so farmers delay the harvest period or throw it into the river (Frilanda et al., 2022). The problem can be resolved through various studies optimising the utilisation of bioactive compounds contained therein such as proteins, fats, organic acids and minerals (Singh et al., 2021; Liu et al., 2023). Especially for dragon fruit plants, some of the research that has been done includes the use of dragon fruit skin as flour in food products such as milk pie (Rahmah et al., 2022), dried bakpia (Nirmalawaty & Mahayani, 2020) and cookies (Triwulandari et al., 2017; Kumalasari & Devira, 2024), natural colouring (Regilia et al., 2024), preserving food products (Oktiarni et al., 2012; Nirmalawaty & Mahayani, 2020) and identifying the presence of borax (Darmawati et al., 2023; Novianty, 2023).

The utilisation of dragon fruit peels in the form of flour added or substituted in food products has often been applied because of its easy manufacturing process, besides that red dragon fruit peels have higher free radical scavenging activities than the fruit flesh and contain betalains in addition to anthocyanins. Betalain

How to Cite:
Wulandari, A., & Nirmalawaty, A. (2025). Improving Waffle Quality through Substitution of Dragon Fruit Peel Flour. *Jurnal Penelitian Pendidikan IPA*, *11*(9), 479–486. https://doi.org/10.29303/jppipa.v11i9.12126

is a pigment that is only found in plants from the order Caryophyllales, and does not experience damage when extracted at 1000C. Betalains consist of betasianin and betaxanthin (Rebecca et al., 2008).

In general, the results of previous studies show that the more dragon fruit skin flour (TKBN) added or substituted, the higher the fibre content and antioxidant activity in food products (cookies, pancakes and cakes) but there is a decrease in the level of panelist preference (Ho & Latif, 2016; Lianawati & Warsito, 2019; Rahayu, 2021; Bimo et al., 2022; Chumroenvidhayakul et al., 2023; Rahmah et al., 2022). In these various studies, the determination of the recommended number of TKBN is not proven empirically, only adjusted to the researcher's hypothesis. Empirical proof can be done through the de Garmo method effectiveness test (Degarmo, 1984). Based on this test, the best treatment is determined based on a combination of sensory tests, physical and chemical properties of food products. This research aims to determine the best TKBN substitution percentage for waffles as an effort to improve their quality through the de Garmo effectiveness test.

Method

Sample Preparation

The research was conducted at the Integrated Food Laboratory, Faculty of Vocational Studies, Universitas 17 August 1945 Surabaya from May to June 2024. The treatments consisted of 4 (four) levels of wheat flour substitution with TKBN, namely 0% (P0), 3% (P1), 6% (P2), and 9% (P3) with 4 replications. The waffle formulation is presented in table 1. Preparation of dragon fruit flour refers to Nirmalawaty et al. (2020). The observation variables consisted of physicochemical properties test, including crispness (texture, penetrometer method), moisture content (OAOC, 2005), fat content (Soxhlet method - semi-automatic), total ash content (muffle furnace method 600-1000C), protein content (AOAC, 1970), carbohydrate (by difference) and organoleptic test which includes the level of panelist preference for colour, aroma, taste and texture.

Table 1. Formulations Waffle

Ingredients	Treatments			
	P0	P1	P2	P3
Margarine	100 g	100 g	100 g	100 g
Liquid milk	75 ml	75 ml	75 ml	75 ml
Egg	2 pcs	2 pcs	2 pcs	2 pcs
Wheat Flour	175 g	169.7 g	164.5 g	159.3 g
Dragon Fruit Peel Flour	0 g	5.25 g	10.5 g	15.7 g
Whipped Cream	75 ml	75 ml	75 ml	75 ml
Baking Powder	8 g	8 g	8 g	8 g
Vanilla	1 g	1 g	1 g	1 g
Sugar	100 g	100 g	100 g	100 g

Sensory test data were transformed using the MSI method before analysis of variance using the RAL method followed by a t-test at the 95% confidence level. The recommended treatment is done through the determination of Effectiveness Test (Degarmo, 1984). The formulas of effectiveness value (NE), productivity value (NP) and Effectiveness Test are as follows:

$$\mathrm{NE} = \frac{\mathrm{NPH} - \mathrm{NTKH}}{\mathrm{NTBK} - \mathrm{NSH}} \rightarrow \mathrm{NP} = \mathrm{NE} \times \mathrm{BV} \quad (1)$$

$$\text{Effectiveness Test} = \sum \mathrm{NP}_1 + \sum \mathrm{NP}_2 + \sum \mathrm{NP}_3 \quad (2)$$

NE = value of each treatment in organoleptic, physical and chemical tests.
NPH = average value of observations of each treatment in organoleptic, physical and chemical tests.
NTKH = the smallest value of each treatment in organoleptic, physical and chemical tests.
NTBH = the largest value of each treatment in organoleptic, physical and chemical tests.
NSH = best and worst average difference value of each treatment in organoleptic, physical and chemical tests.
NP = productivity value of each treatment in organoleptic, physical and chemical tests.
BV = Weight of each treatment in organoleptic, physical and chemical tests.
$\sum \mathrm{NP}_1$ = Total NP of each organoleptic test treatment.
$\sum \mathrm{NP}_2$ = Total NP of each physical test treatment.
$\sum \mathrm{NP}_3$ = Total NP of each chemical test treatment

Result and Discussion

Physicochemical Test

Physicochemical tests observed included moisture content, texture, protein, fat content, fibre and ash content and carbohydrates. The results of laboratory analysis showed that TKBN substitution had a significant effect on all physicochemical variables (Table 2) where the increasing TKBN substitution decreased the moisture content and fat content of the waffle, while the protein, fibre, ash and carbohydrate content increased.

The moisture content of waffle decreases with the greater the percentage of TKBN substitution of waffle. The highest waffle moisture content in the control treatment is 24.06% and the lowest in the P3 treatment is 22.17%. The moisture content of both the control treatment and TKBN substitution met the quality standards of semi-wet cakes, which is a maximum of 40% (SNI 01-2973-2011). The results of this study are in line with Ho et al. (2016) research on cookies where the increase in TKBN substitution decreased the moisture content and water activity (aw). The decrease in water activity is due to TKBN having a fibre component that is able to retain a certain amount of water, thus reducing the amount of water available. A decrease in water content has a positive impact on the shelf life of food products, considering that low water content will inhibit microbial activity in breaking down carbohydrates (Rahmah et al., 2022).

Table 2. The Results of Laboratory Analysis

Treatment	Moisture Content (%)	Texture (g/cm²)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrates (%)
P0	24.0585 a	119.45 a	2.2447 a	0.3865 a	1.2842 a	0.4763 a	72.0693 a
P1	24.0158 b	118.40 b	2.5950 b	0.3860 a	1.3447 b	0.5535 b	71.6808 b
P2	23.6510 c	116.00 c	2.7293 c	0.3580 ab	1.3855 c	0.6798 c	71.8763 c
P3	22.1680 d	105.25 d	3.0205 d	0.3205 b	1.6445 d	0.7757 d	72.7815 d

The texture/softness of the waffle was determined by the penetrometer method, where the lower the pressure resistance on the product, the depth of the penetrometer needle penetrates the waffle deeper, resulting in a higher level of softness. The results showed that the level of tenderness of the waffle was influenced by the percentage of TKBN substitution, where the greater the percentage of TKBN substitution, the harder the waffle. This is due to the reduced percentage of flour in the dough so that it will affect the glutenisation process where the reduced gluten in the dough will reduce the ability to hold gas so that it cannot form the desired dough structure (Nirmalawaty & Mahayani, 2020; Triwulandari et al., 2017).

Based on Table 2, the protein content in dragon fruit peel flour waffles in all treatments averaged 2-3% and there were significant differences between treatments, where the greater the substitution of dragon fruit peel flour, the higher the protein content. Simangungsong (2014) stated that the protein content of TKBN was 8.98 ± 0.01%, while Hotmaida et al. (2020) obtained a smaller protein value of 6.38% and Aprilia et al. (2021) mentioned 5.08%. This difference may be due to the type of dragon fruit and the processing method. TKBN substitution also significantly affected the carbohydrate content of waffles (Table 2) where the average carbohydrate content of waffles was 72.1%. The same thing was obtained by Hotmaida et al. (2020), while Ramil et al. (2021) obtained a greater value of 73.8%. The presence of these carbohydrates indicates the potential presence of starch in TKB, which contains amylose and amylopectin. Unfortunately, information on amylose and amylopectin in YKBN is still very limited (Hotmaida & Sutrisno, 2020).

Fat is a macronutrient component that determines the quality of a food product. Substitution of dragon fruit peel flour had a significant effect on the fat content of waffles, where the fat content decreased with increasing percentage of dragon fruit peel flour substitution (Table 2), where the lowest fat content was obtained in the P3 treatment but not significantly different from the P2 treatment. This is in line with the research of Chumroenvidhayakul et al. (2023) where the addition of TKBN by 1%, 2%, and 5% b/b of cookie dough significantly increased the phenolic content and total betasianin and antioxidant activity, while reducing malondialdehyde and dietary advanced glycation end products (dAGE). The addition of TKBN resulted in reduced starch digestibility, hydrolysis index and glycaemic index.

Fibre content in TKBN substituted waffles was highest in P3 (9%) at 0.77% (Table 2). This is in line with research Ho et al. (2016), which showed that cookies with the addition of white dragon fruit peel flour had higher fibre content than the control. Dragon fruit skin contains 69.3% insoluble dietary fibre (IDF) and 14.8% soluble dietary fibre (SDF) (Jamilah et al., 2011). Dietary fibre is part of plant material in food that is resistant to enzymatic digestion (Debnath et al., 2025; Fadillah et al., 2024) so dragon fruit skin is good for human health because it is one of the natural functional food ingredients that has a high total dietary fibre so that the more it is used, the higher the fibre content of dragon fruit skin flour waffles.

As with fibre, protein and carbohydrate content, ash content increased with increasing TKBN substitution (Table 2). Unlike root flours such as mocaf, TKBN has a high ash content. This ash content is closely related to the mineral content in dragon fruit skin. The high mineral content in dragon fruit skin is influenced by evaporation during the drying process, where the more water evaporates, the more minerals are left behind and the ash content will increase (Hotmaida & Sutrisno, 2020; Septian et al., 2024).

Organoleptic Test

All organoleptic test data (colour, taste, texture, and aroma) were transformed using the MSI (Method of Successive Interval) method before variance analysis was performed because organoleptic test data are ordinal data (Nur, 2019; Suparno et al., 2022). TKBN substitution resulted in a colour change from brownish yellow to reddish brown in the waffles. The appearance of a reddish colour in dragon fruit peel flour substitution is due to the presence of natural pigments anthocyanins and betanins in sufficient quantities. The betanin content in dragon fruit peel extract was 9.44 ± 0.01 mg/g sample, while the anthocyanin content was 19.21 ± 0.01 mg/g sample (Khoo et al., 2022; Fadiyah et al., 2024), whereas Nizori (2020) reported that the anthocyanin content in dragon fruit peel extract was 6.03 ± 0.45 mg/50 samples. The betanin and anthocyanin content in dragon fruit peel is higher than that in the fruit flesh. However, dragon fruit peel has lower antioxidant activity as a free radical scavenger compared to the fruit flesh (Khoo et al., 2022; Bhagya Raj et al., 2022).

Table 3 shows that the panelists' preference decreased with increasing substitution of dragon fruit peel flour. The highest level of preference for waffle colour was observed in treatment P0, where the higher the percentage of dragon fruit peel flour substitution, the darker/brown the waffle colour became (Figure 1). This is due to anthocyanins being highly sensitive to pH changes and heat (Nizori, 2020; Amrih et al., 2023).

Table 3. Organoleptic Waffle Test

Treatment	Colour	Texture	Taste	Aroma
P0	4.0 a	4.2 a	3.4 a	3.9 a
P1	3.9 a	4.2 a	4.2 b	3.8 a
P2	3.9 a	3.8 ab	4.2 b	3.9 a
P3	3.2 b	3.4 b	3.5 a	2.9 b

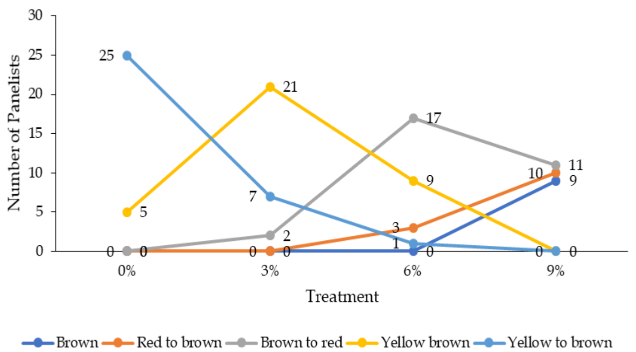

Figure 1. Histogram of panelists' percentage of preference for waffle colours

The TKBN production process refers to Rizkiana et al. (2024) research, where the temperature used was 60°C for approximately 20 hours. Nasrullah et al. (2020) mentioned that anthocyanin pigments are stable at temperatures ranging from 40 to 50°C with heating times of 30, 45, and 60 minutes. If the heating process is carried out over a longer period of time, pH changes occur, leading to the degradation of anthocyanin pigments from the aglycone form to chalcone (colourless) (Nizori , 2020; Amrih et al., 2023).

The panelists' preference for waffle texture decreases as the substitution of dragon fruit peel flour increases; however, the panelists still accept the waffle texture up to a 6% substitution (Table 3). Increasing dragon fruit peel flour substitution altered the waffle texture from soft to hard, as shown in Figure 2. This is because red dragon fruit peel contains high levels of fibre, with a soluble dietary fibre to insoluble dietary fibre ratio of 1:3.8 to 1:4.68 (Hernawati et al., 2018; Jamilah et al., 2011).

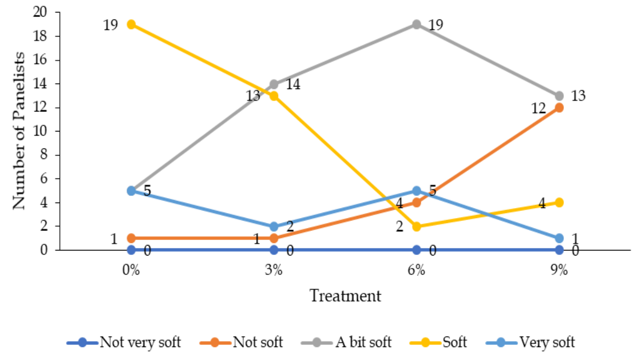

Figure 2. Histogram of panelists' percentage of preference for waffle texture

The results of the transformation of panelists' preference levels for waffle taste show that the highest average was obtained in treatments P1 and P2, where treatments P1 and P2 were significantly different from treatments P0 and P3 (Table 3). This means that panelists can still accept waffle taste with a 6% substitution of TKBN, as concluded by Bimo et al. (2022) in chiffon cake. This decrease in liking level was caused by a slightly bitter and astringent taste due to the increasing substitution of dragon fruit peel, as found in the study by Nirmalawaty et al. (2020) on dried bakpia. This bitter taste arises due to the presence of tannins, alongside alkaloids, steroids, and saponins (Noor et al., 2016), which are associated with glycoproteins (Kumalasari & Devira, 2024; Bhagya Raj et al., 2022).

The panelists' preference for the aroma of waffles treated with P0, P1, and P2 was not significantly different, and all three were significantly different from P3 (Table 3), indicating that the aroma of waffles with substitution above 6% was not preferred by the panelists. In the treatment with 9% TKBN substitution, an unpleasant aroma was detected compared to the other treatments. This unpleasant aroma is likely caused by the action of lipoxygenase enzymes interacting with oxygen naturally present in red dragon fruit, specifically in its skin, as well as the activity of lipoxygenase enzymes that can oxidise unsaturated fatty acid chains (Kumalasari & Devira, 2024; Adelina et al., 2025).

Effectiveness Test

The effectiveness value Degarmo (1984) was determined to establish the optimal TKBN substitution in food products, particularly waffles. In physical-chemical tests, TKBN substitution significantly affected all variables, where a higher substitution percentage resulted in a decrease in moisture content, texture (waffle softness), and fat content, while increasing protein, ash, fibre, and carbohydrate content. All organoleptic test variables were influenced by TKBN substitution (Table 2). Treatment P3 was less preferred in terms of colour, texture, taste, and aroma, but substitution up to 3% was still preferred because it produced colour, texture, and aroma that were not significantly different from the control, and even resulted in a better taste (Table 4).

Table 4. Effectiveness Test of Waffles on Various TKBN Substitutions

Variable			0%		3%		6%		9%
	BV	NE	NP	NE	NP	NE	NP	NE	NP
Colour	0.31	1.19	0.37	0.88	0.28	1	0.31	0	0
Aroma	0.1	1	0,1	0.6	0.06	0.48	0.05	0	0
Taste	0.26	1	0.26	0.53	0.14	0	0	0.18	0.05
Texture	0.33	0	0	0.63	0.21	1	0.33	0.19	0.06
Subtotal			0.73		0.68		0.69		0.11
Penetrometer	0.56	1	0.56	0.93	0.51	0.76	0.42	0	0
Moisture Content	0.44	0.98	0.01	1	0	0.78	0.1	0	0.44
Subtotal			0.57		0.51		0.52		0.44
Protein	0.13	0	0	0.45	0.06	0.62	0.08	1	0.13
Fat	0.14	0	0	0.01	0	0.43	0.06	1	0.14
Fiber	0.24	0	0	0.26	0.06	0.68	0.17	1	0.24
Carbohydrates	0.18	0.65	0.12	1	0.18	0.82	0.15	0	0
Ash	0.3	0	0	0.17	0.05	0.28	0.08	1	0.3
Subtotal			0.12		0.36		0.54		0.82
Total			1.41		1.56		1.75		1.37

The weighting of each variable was then determined based on a survey of the panelists. The panelists stated that the colour of the waffle was the most important variable in the organoleptic test, followed by texture, taste and aroma. In the physical-chemical test, the panelists stated that texture (softness measured using a penetrometer) was more important than the moisture content of the waffle, and mineral and fibre content were the most important variables because the panelists hoped that through the substitution of TKBN, the fibre and mineral (ash) content in flour-based food products could be increased. Based on the de Garmo effectiveness test, the highest productivity value (NP) for the organoleptic and physical tests of waffles was obtained in the control treatment (P0), while treatment P3 (9%) had the highest productivity value (NP) from the sum of the chemical tests. After combining the results of the three tests (organoleptic, physical, and chemical), treatment P2 (6% substitution) had the highest value, which was 1.75 (Table 4). Based on the effectiveness test, the TKBN substitution rate for waffles is 6% of the wheat flour requirement. This recommendation aligns with the findings of Bimo et al. (2022) on chiffon cake and (Nirmalawaty & Mahayani, 2020) on dried bakpia. A higher percentage of TKBN substitution, as concluded by several other researchers, such as Kumalasari & Devira (2024), which is 31%, can be applied if wheat flour is mixed with flour from legumes or tubers other than TKBN.

Conclusion

The maximum substitution limit of dragon fruit peel flour in waffles is 6% because the waffles are still preferred and have a physical appearance that is not different from the control treatment. Compared to the control treatment, the substitution of 6% dragon fruit peel flour significantly increased the fibre, protein, carbohydrate, and ash content while also reducing the fat content, although not significantly statistically.

Acknowledgments
We are very grateful to the Institute for Research and Community Service (LP2M) of the University of 17 Agustus 1945 Surabaya for the financial support provided for the implementation of this research grant.

Author Contributions
A.W.: conceptualized the research, research procedures, analyzed the data and wrote the article; A.N.: supervised the writing of the article, reviewed and validated the research instruments used.

Funding
The Institute for Research and Community Service (LP2M) of the University of 17 Agustus 1945 Surabaya.

Conflicts of Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abidin, A. (2025). *Musim Panen Harga Buah Naga Anjlok, Petani di Tegaldlimo Banyuwangi Ketar-Ketir*. Radar Banyuwangi. Retrieved from https://radarbanyuwangi.jawapos.com/genteng/755663236

Adelina, N. M., Giovani, S., Jameelah, M., Hidayanti, Y. F., Zahra, S. F., & Rosianajayanti. (2025). Sensory Characteristics and Nutritional Content of Dragon Fruit Peel Cookies with Stevia Substitution. *Journal of Applied Food Technology, 12*(1), 14-22. Retrieved from https://ejournal2.undip.ac.id/index.php/jaft

Amrih, D., Syarifah, A. N., Marlinda, G., Budiarti, P., Safitri, A., & Nugraha, I. S. A. (2023). Pengaruh Pemanasan Terhadap Perubahan Warna pada Pangan. *J Innov Food Technol Agric Prod*, *1*, 1–4. https://doi.org/10.31316/jitap.vi.5781

Aprilia, T., & Rakhmawati, R. (2021). Quality Improvement of Feed Chemical Composition with the Addition of Dragon Fruit Skin Flour (Hylocereus polyrhizus). *E-Jurnal Rekayasa dan Teknologi Budidaya Perairan*, *9*, 1101. https://doi.org/10.23960/jrtbp.v9i2.p1101-1108

Bhagya Raj, G. V. S., & K Dash, K. (2022). Dragon fruit peel extract microcapsule incorporated pearl millet and dragon fruit pulp powder based functional pasta: formulation, characterization, and release kinetics study. *Food Sci Biotechnol, 32*(6), 779–792. https://doi.org/10.1007/s10068-022-01220-x

Bimo, B., Saptariana, S., Rosidah, R., & Wahyuningsih, W. (2022). Eksperimen Pembuatan Chiffon Cake Substitusi Tepung Kulit Buah Naga Merah (Hylocereus polyrhizus) pada Kesukaan Masyarakat, Kandungan Vitamin C, dan Flavonoid. *TEKNOBUGA J Teknol Busana dan Boga*, *10*(2), 150–158. https://doi.org/10.15294/teknobuga.v10i2.37543

Chumroenvidhayakul, S., Thilavech, T., Abeywardena, M., & Adisakwattana, S. (2023). Dragon Fruit Peel Waste (Hylocereus undatus) as a Potential Ingredient for Reducing Lipid Peroxidation, Dietary Advanced Glycation End Products, and Starch Digestibility in Cookies. *Antioxidants*, *12*. https://doi.org/10.3390/antiox12051002

Darmawati, D., Usman, U., Nur, N. E., Nursamsi, N., & Asri, M. (2023). Identifikasi Boraks dengan Indikator Alami Ekstrak Kulit Buah Naga (Hylocereus polyrhizus) pada Jajanan Bakso di Kecamatan Galang. *J Kolaboratif Sains*, *6*, 393–399. https://doi.org/10.56338/jks.v6i5.2859

Debnath, A., Singh, P. K., & Sharma, Y. C. (2025). Geochemical characterization of heavy metal bearing phases in the sediments of Ganges, India: analyzing the toxicity status of sedimentary environment. *Environmental Monitoring and Assessment, 197*(8), 958. https://doi.org/10.1007/s10661-025-14405-8

Degarmo, E. (1984). *Engineering Economy*. New York: Mc Millan Publishing Company.

Fadillah, R., Agustina., Pagoray, H., Saptiani, G., & Reynalta, R. (2024). Supplementation of red dragon fruit (Hylocereus polyrhizus) peels flour as a prebiotic in tilapia (Oreochromis niloticus). *Aquatic Sciences Journal, 11*(3). https://doi.org/10.29103/aa.v11i3.12190

Fadiyah, A. T. H., Sinaga, H., & Lubis, L. M. (2024). The effect of adding dragon fruit peel (*Hylocereus polyrhizus*) and red ginger extract on characteristics of jelly candy from aloe vera. *Advances in Food Science, Sustainable Agriculture and Agroindustrial Engineering, 7*(1), 1-9. https://doi.org/10.21776/ub.afssaae.2024.007.01.1

Fitriansyah, M. N. (2024). *AgroCircle Griya: Solusi Sirkular Limbah Pertanian dan Pertanian Berkelanjutan*. Rakyat Media Id.

Frilanda, A, Putranto, W. S., & Gumilar, J. (2022). Pengaruh Berbagai Konsentrasi Pulp Buah Naga Merah pada Pembuatan Set Yoghurt Terhadap Total Bakteri Asam Laktat, Nilai pH, dan Total Asam. *J Teknol Has Peternak*, *3*(1), 32. https://doi.org/10.24198/jthp.v3i1.39239

Hernawati, H., Setiawan, N. A., Shintawati, R., & Priyandoko, D. (2018). The Role of Red Dragon Fruit Peel (Hylocereus polyrhizus) to Improvement Blood Lipid Levels of Hyperlipidaemia Male Mice. *J Phys Conf Ser*, 1013. https://doi.org/10.1088/1742-6596/1013/1/012167

Ho, L. H., & Latif, N. W. A. (2016). Nutritional Composition, Physical Properties, and Sensory Evaluation of Cookies Prepared from Wheat Flour and Pitaya (Hylocereus undatus) Peel Flour Blends. *Cogent Food Agric*, 2. https://doi.org/10.1080/23311932.2015.1136369

Hotmaida, Y., & Sutrisno, S. (2020). Non-Destructive Determination of the Main Chemical Components of Red Dragon Fruit Peel Flour by Using Near-Infrared Reflectance Spectroscopy (NIRS). *IOP Conf Ser Earth Environ Sci*, *542*. https://doi.org/10.1088/17551315/542/1/012007

Jamilah, B., Shu, C. E., Kharidah, M., Dzulkifly, M. A., & Noranizan, A. (2011). Physico-Chemical Characteristics of Red Pitaya (Hylocereus polyrhizus) Peel. *International Food Research Journal*, *18*, 279–286. Retrieved from http://psasir.upm.edu.my/16208/1/16208.pdf

Khoo, H. E., He, X., Tang, Y., Li, Z., Li, C., & Zeng, Y. (2022). Betacyanins and Anthocyanins in Pulp and Peel of Red Pitaya (Hylocereus polyrhizus cv.

Jindu), Inhibition of Oxidative Stress, Lipid Reducing, and Cytotoxic Effects. *Front Nutr*, *9*, 1–11. https://doi.org/10.3389/fnut.2022.894438

Kumalasari, D. I., & Devira, A. (2024). Aktivitas Antioksidan dan Evaluasi Sensori Kukis Tersubstitusi Tepung Kacang Hijau dan Tepung Kulit Buah Naga Merah. *J Teknol dan Ind Pangan*, *35*(1), 67–78. https://doi.org/10.6066/jtip.2024.35.1.67

Lianawati, H. T. W., & Warsito, H. (2019). Pembuatan pancake subtitusi tepung kulit buah naga merah sebagai makanan selingan sumber antioksidan dan serat bagi penderita diabetes mellitus tipe 2. In *Prosiding Seminar Nasional INAHCO 2019* (Vol. 1). Retrieved from https://publikasi.polije.ac.id/inahco/article/view/1787

Liu, Z, Souza, T. S. P. D., Holland, B., Dunshea, F., Barrow, C., & Suleria, H. A. R. (2023). Valorization of Food Waste to Produce Value-Added Products Based on Its Bioactive Compounds. *Processes*, *11*. https://doi.org/10.3390/pr11030840

Nasrullah, N., Husain, H., & Syahrir, M. (2020). Pengaruh Suhu dan Waktu Pemanasan Terhadap Stabilitas Pigmen Antosianin Ekstrak Asam Sitrat Kulit Buah Naga Merah (Hylocereus polyrizus) dan Aplikasi pada Bahan Pangan. *Chem J Ilm Kim dan Pendidik Kim*, *21*, 150. https://doi.org/10.35580/chemica.v21i2.17985

Nirmalawaty, A., & Mahayani, A. P. S. (2020). Analisa Kimia Bakpia Kering Substitusi Tepung Kulit Buah Naga. *Stigma*, *13*(1), 15-23. https://doi.org/10.36456/stigma.13.1.2418.15-23

Nizori, A. (2020). Karakteristik Ekstrak Kulit Buah Naga Merah (Hylocereus polyrhizus) dengan Penambahan Berbagai Kosentrasi Asam Sitrat Sebagai Pewarna Alami Makanan. *J Teknol Ind Pertan*, *30*, 228–233. https://doi.org/10.24961/j.tek.ind.pert.2020.30.2.228

Noor, M. I., Yufita, E., Fisika, J., Matematika, F., & Pengetahuanalam, I. (2016). Identifikasi kandungan ekstrak kulit buah naga merah menggunakan Fourier Transform Infrared (FTIR) dan fitokimia. *Journal of Aceh Physics Society (JAcPS),* *5*(1), 14-16. Retrieved from https://media.neliti.com/media/publications/91926-ID-none.pdf

Novianty, N. (2023). Deteksi Formalin pada Tahu Menggunakan Ekstrak Antosianin dari Kulit Naga (Hylocereus polyrhizus). *Masker Med*, *11*, 190–194. https://doi.org/10.52523/maskermedika.v11i1.535

Nur, A. A. (2019). *Tutorial Transformasi Data Ordinal Menjadi Data Interval dengan Method of Successive Interval (MSI)*. https://doi.org/10.13140/RG.2.2.15247.94888

Oktiarni, D., Ratnawati, D., & Anggraini, D. Z. (2012). Pemanfaatan ekstrak kulit buah naga merah (Hylocereus polyrhizus sp.) sebagai pewarna dan pengawet alami mie basah. *Jurnal Gradien, 8*(2), 819-824. Retrieved from https://shorturl.at/8BX4K

Rahayu, R. (2021). Pengaruh Substitusi Tepung Kulit Buah Naga (Hylocereus polyrhizuz) Terhadap Aktivitas Antioksidan, Kandungan Gizi dan Organoleptik Bolu Kukus. *J. Sains dan Teknol Pangan*, *6*, 3629–3640.

Rahmah, L., Ansori, A. N. M., Choiriyah, N. A., Iskandar, H. T., Hadiwirawan, G. Y., & Rebezov, M. (2022). Substitution of Dragon Fruit Peels on Vitamin C, Water content, and Fiber in Milk Pie to Improve Human Health. *Res J Pharm Technol*, *15*, 3690–3696. https://doi.org/10.52711/0974-360X.2022.00619

Ramil, M. D. I., Mendoza, A. M. D. C., & Ramil, R. J. D. (2021). Assessment on the Physicochemical and Phytochemical Properties, Nutritional and Heavy Metal Contents, and Antioxidant Activities of Hylocereus polyrhizus Peel from Northern Philippines. *Indian J Sci Technol*, *14*, 1097–1104. https://doi.org/10.17485/ijst/v14i14.2286

Rebecca, O. P. S., Zuliara, R., Boyce, A. N., & Chandran, S. (2008). Determining Pigment Extraction Efficiency and Pigment Stability of Dragon Fruit (Hylocereus polyrhizus). *J Biol Sci*, *8*, 1174–1180. https://doi.org/10.3923/jbs.2008.1174.1180

Regilia, D., Darmawan, E., & Laswati, D. T. (2024). Pemanfaatan Buah Naga Merah (Hylocereus polyrhizus) Sebagai Pewarna Alami dan Sumber Antioksidan Pada Bolu Kukus. *Agrotech: Jurnal Ilmiah Teknologi Pertanian,* *6*(2), 19-26. https://doi.org/10.37631/agrotech.v6i2.1695

Rizkiana, N. D., Fitria, S., & Ridwan, B. (2024). Perbedaan Suhu Dehidrator Terhadap Rendemen, Warna, Kadar Air dan Organoleptik pada Pembuatan Tepung Kulit Buah Naga Merah. *J Ilm Ilmu dan Teknol Rekayasa*, *6*, 52–59. https://doi.org/10.31962/jiitr.v6i2.185

Septian, H., Popalia, N., & Mutmainnah. (2024). Utilization of Dragon Fruit Peel as a Natural Gelling Agent. *Journal of Toque and Apron,* *1*(1). https://doi.org/10.33649.v1i1.2511

Simangungsong, S. (2014). Kajian Kandungan Zat Makanan dan Pigmen Antosianin Tiga Jenis Kulit Buah Naga (Hylocereus sp.) sebagai Bahan Pakan Ternak. *Repository*, *41*, 357–364. https://doi.org/10.7868/s0132344x15060031

Singh, R., Das, R., & Sangwan, S. (2021). Utilisation of Agro-Industrial Waste for Sustainable Green Production: A Review. *Environmental Sustainability*, *4*, 619–636. https://doi.org/10.1007/s42398-021-00200-x

Suparno, Fatmawati, D., Fitriani, N. R., Rahman, A., Tarigan, S. M., Faridawaty, E., Sadono, A., Gunawan, W. B., Yan Nurrezkytaku A., Kumalawati, D. A., Dewi, R. S., & Sanjaya, A. R. D. P. (2022). Effect of Various Red Dragon Fruit Peel (Hylocereus polyrhizus) and Yellow Pumpkin (Cucurbita moschata) Combinations and Carrageenan Proportion on the Quality of the Jam. *Nutr Clín Diet Hosp*, *42*(4), 182-189. https://doi.org/10.12873/424suparno

Triwulandari, D., Mustofa, A., & Karyantina, M. (2017). Karakteristik Fisikokimia dan Uji Organoleptik Cookies Kulit Buah Naga (Hylocereus undatus) dengan Subtitusi Tepung Ampas Tahu. *Jurnal Teknologi dan Industri Pangan*, *2*, 61–66. https://doi.org/10.33061/jitipari.v2i1.1537