

PHYSICOCHEMICAL AND ORGANOLEPTIC QUALITY ANALYSIS OF GLUTEN-FREE WET NOODLES BASED ON SORGHUM FLOUR (*SORGHUM BICOLOR* L. MOENCH)

Daniel Eka Bekti Saputra^{1*}, Fadjar Kurnia Hartati², Adhania Andika Prayudanti³

Fakultas Teknologi Pangan dan Perikanan / Universitas Dr. Soetomo, Surabaya^{1,2,3}

E-mail: dansaputraone@gmail.com¹, fadjar.kurnia@unitomo.ac.id², adhania@unitomo.ac.id³

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Abstract

Dependence on wheat flour in Indonesia encourages efforts to develop local food ingredients such as sorghum which has a low glycemic index and high antioxidant content. However, the absence of gluten causes sorghum noodle dough to be less flexible and easily broken, so natural binding agents such as apple peel puree containing pectin, soluble dietary fiber, and polyphenols are needed to improve the dough structure. This study aims to analyze the physicochemical and organoleptic qualities of gluten-free wet noodles using sorghum flour as the main ingredient and the addition of apple peel puree as a source of fiber and bioactive compounds. The study used a quantitative laboratory experimental method with a Completely Randomized Design (CRD) consisting of 4 levels of sorghum flour/ S and apple peel puree/ P formulation treatments (S1P1 90:10, S2P2 80:20, S3P3 65:35, S4P4 50:50) with three replications. The parameters observed included protein content, crude fiber content, noodle flexibility, and organoleptic tests (color, aroma, taste, texture). All data were analyzed using ANOVA, if there was a significant or very significant difference, further testing was carried out. Parametric data using BNT/BNJ/Duncan depending on the KK value, while non-parametric data using Kruskal Wallis test followed by effectiveness test. The results showed that the S1P1 treatment (90% sorghum flour: 10% apple peel puree) was the best treatment based on the effectiveness test with the highest yield value (NH) of 0.72. This treatment produced wet noodles with characteristics of 10.42% protein content, 1.51% crude fiber content, and tensile *strength value* of 0.84 N, and organoleptically preferred by panelists in the parameters of color (4.29), aroma (3.66), taste (4.49), and elasticity (4.39).

Keywords : *Wet noodles; Gluten-free; Sorghum flour; Apple peel puree*

INTRODUCTION

Noodles are a widely consumed food in Indonesia, even ranking second in the world for instant noodle consumption (WINA, 2023). High noodle consumption leads to a dependence on wheat imports, necessitating the need for alternative local food sources. Sorghum (*Sorghum bicolor* L. Moench) has great potential as a noodle raw material due to its low glycemic index, high protein content, and rich phenolic compounds and antioxidants (Suarni, 2016; Awika, 2017). However, the absence of gluten in sorghum causes the resulting noodles to be less elastic, break easily, and become brittle (Xing et al., 2021; Syifahaque et al., 2023; Ejiofor & Beleya, 2023). One way to improve the structure of gluten-free noodles is by adding hydrocolloids as a gluten substitute. Pectin is a natural hydrocolloid obtained from fruit peel waste, including apple peels (*Malus domestica*). Apple peels are known to be rich in fiber, pectin, and phenolic compounds, which have the potential to improve the texture and functional value of food products (Henríquez et al., 2010; Kaur et al., 2022). The addition of pectin has been shown to increase structural stability and improve the texture of gluten-free products (Abdollahzadeh et al., 2023). Previous studies generally used apple peel powder, which tends to increase dough hardness. Conversely, the use of apple peel puree is potentially more effective because it contains water, soluble fiber, and natural pectin, which can increase dough plasticity and flexibility. The pectin in the puree acts as a *gelling agent* that forms a gel network between starch granules, thereby improving the structure of gluten-free noodles (Padalino et al., 2013). To date, research on the use of apple peel puree in sorghum flour-based wet noodles is still limited, creating a *research gap* that needs to be explored. Therefore, this research is important to improve the physicochemical, sensory, and functional quality of sorghum noodles, while also supporting local food diversification (Philia et al., 2020).

LITERATURE REVIEW

Wet Noodles

Wet noodles are a food product made from wheat flour with or without permitted food additives, have a high water content, and are consumed after being boiled or steamed (SNI 2987:2015). The manufacturing process includes mixing, stirring, forming sheets, cutting, and cooking. Wet noodles are a popular flour-based product because they are easy to process, economical, and flexible to combine with local foodstuffs such as sorghum (Fu, 2021). Nutritionally, wet noodles are predominantly carbohydrate-based as an energy source, with a relatively low fat content (TKPI, 2018).

Wet Noodle Quality Standards

Wet noodle quality standards are established to ensure product safety and quality, encompassing sensory, chemical, and food safety aspects. Based on SNI 2987:2015, wet noodles must have a normal odor, taste, color, and texture, a maximum water content of 35% for raw noodles and 65% for cooked noodles, and a minimum protein content of 9% (raw) and 6% (cooked). Testing for hazardous contaminants such as formaldehyde and borax is mandatory to ensure safe consumption (BSN, 2015).

Sorghum (*Sorghum bicolor* L. Moench)

Sorghum is a cereal crop that is adaptable to drought and marginal land, thus potentially supporting food security (Tanwar et al., 2023). Sorghum grains consist of the pericarp, endosperm, and embryo, with the pericarp rich in fiber and tannins that influence processing properties (Mohamed et al., 2022). Nutritionally, sorghum contains complex carbohydrates, protein, dietary fiber, and bioactive compounds such as phenolics and flavonoids that function as antioxidants (Hassan, 2023). Its gluten-free nature and low glycemic index make sorghum suitable as a functional food ingredient (Needham, 2024).

a. Sorghum Flour

Sorghum flour is obtained by milling milled sorghum grains. The physicochemical characteristics of flour are influenced by the variety and milling process. Flour with a finer particle size and minimal pericarp results in better dough performance (Curti et al., 2021). However, because it does not contain gluten, sorghum flour-based dough tends to be less elastic, requiring the addition of hydrocolloids or binders (Célia et al., 2022). Sorghum flour is also rich in minerals, fiber, and phenolic compounds, which enhance the product's functional value (USDA, 2024; Bukonja et al., 2025).

b. Sorghum Flour Quality Standards

Sorghum flour quality standards are regulated in SNI 7622-2011, which covers ash, protein, fat, crude fiber, color, and particle size content. This standard is essential to ensure consistent flour quality as a raw material for food products (Codex, 1989).

Apple Peel

Malus domestica) peel is a part of the fruit rich in dietary fiber, pectin, vitamins, minerals, and antioxidant compounds such as flavonoids and polyphenols. Approximately 50% of apple antioxidant compounds are found in the peel, making it potentially developed as a functional food ingredient (Hikmah et al., 2025). The quality of fruit puree, including apple peel puree, is regulated by SNI 7841:2022, which covers sensory aspects, pH, dissolved solids, and heavy metal contamination limits (BSN, 2022).

Noodle Quality Analysis

Noodle quality analysis included chemical and sensory analysis. Protein content was analyzed using the internationally recognized Kjeldahl method for its high accuracy (Mæhre et al., 2018). Crude fiber content was used as an indicator of food quality and functional benefits (Hermayanti et al., 2016).

Organoleptic Test

Organoleptic testing is used to assess consumer acceptance of sensory attributes such as taste, aroma, color, and texture. This method relies on human sensory perception and is a key indicator of a product's success in the market (Erungan et al., 2010; Tarwendah et al., 2017). The number of panelists and the assessment scale refer to SNI 01-2346-2006.

Effectiveness Test

Effectiveness testing is used to determine the best treatment based on several quality parameters with different units. This method normalizes the data into a unitless index, which is then calculated as the Yield Value (YV). The treatment with the highest YV value is declared the best treatment (DeGarmo et al., 1984).

RESEARCH METHODS

This research is a quantitative laboratory experimental study aimed at analyzing the physicochemical and organoleptic qualities of sorghum wet noodles with the addition of apple peel puree. The research was conducted starting in November 2025, with the manufacturing process and chemical analysis carried out at the Chemistry Laboratory of Trunojoyo University, Madura, while the organoleptic test was carried out at the Tristar Institute Surabaya. The experimental quantitative method was used to test the cause-and-effect relationship by providing treatments in the form of varying concentrations of apple peel puree on the characteristics of wet noodles, the results of which were measured objectively and quantitatively (Waruwu et al., 2025). The research design used was a one-factor Completely Randomized Design (CRD) with four levels of treatment variations of sorghum flour/S and apple peel puree/P, namely 95%:5%, 80%:20%, 65%:35%, and 50%:50%, with a total dough of 200 g. Each treatment was repeated three times, resulting in 12 experimental units. The use of CRD was chosen because the research conditions were relatively homogeneous and this design has advantages in simplicity of analysis and efficiency of degrees of freedom from error (Hasdar et al., 2021). The number of replications was determined based on practical considerations and laboratory efficiency, with reference to Malau (2005) who stated that three replications are sufficient under controlled laboratory conditions.

The main ingredients used in making wet noodles include sorghum flour, apple peel puree, eggs, salt, water, and xanthan gum. Apple peels were obtained from fresh peeled apples in the Pesanggrahan area, Batu City, while Timur Rasa brand sorghum flour was obtained through online stores. The process of making apple peel puree included washing, peeling, cutting, weighing, and crushing using a blender with the addition of hot water, which was modified from the method of Dana and Sonia (2024). The selection of the level of apple peel puree addition refers to research by Jha et al. (2020) and Gumul et al. (2023), which stated that the addition of apple by-products can increase fiber and bioactive compound content, although at high concentrations it can affect texture. The production of wet sorghum noodles was based on the formulation by Oktaviana et al. (2024) with several modifications, particularly in the proportions of sorghum flour and apple peel puree. The production steps included mixing the ingredients until smooth, flattening the dough, forming the noodles, boiling at 100 ± 2 °C for 3 minutes, and draining. The final product, the wet noodles, was then analyzed for physicochemical and organoleptic qualities. The observed variables included protein content using the Kjeldahl method and crude fiber content using the gravimetric method according to SNI 01-2891-1992, noodle flexibility using a Texture Analyzer based on the AACC 66-50 method (2000), and organoleptic testing using the hedonic method for color, aroma, taste, and flexibility using 25 panelists with a rating scale of 1–5 (Palka, 2022). Parametric data were analyzed using one-way ANOVA with the help of SPSS version 26, and if there were significant differences, further tests were carried out using DMRT, BNT, or BNJ according to the coefficient of variation value (Akbar et al., 2022). Organoleptic data were analyzed using the nonparametric Kruskal–Wallis test, while the effectiveness test (DeGarmo et al., 1984) was used to determine the best treatment based on the combined result values.

RESULTS AND DISCUSSION

1. Chemical Test

Protein Content

Results of determining protein content in apple skin *puree sorghum noodles* can be seen in Table 1:

Table 1. Average protein content of sorghum noodles and apple skin *puree*

Treatment Code	Test			Total %	Average %
	1	2	3		
S1P1	6.37	6.43	6.59	19.39	6.46 ^a
S2P2	6.93	6.82	6.9	20.65	6.88 ^{ab}
S3P3	7.17	7.04	7.37	21.58	7.19 ^b
S4P4	10.77	9.91	10.57	31.25	10.42 ^c
KK value = 3.22%					

The table shows that variations in the addition of sorghum flour and apple peel puree have a very significant effect on the protein content of sorghum noodles. Treatment S1P1 (90:10) produced the highest protein content of 10.42%, while treatment S4P4 (50:50) produced the lowest protein content of 6.46%. The results showed a decrease in protein content along with increasing concentration of apple peel puree and decreasing proportion of sorghum flour in the noodle formulation. Sorghum flour acts as the main protein source, while apple peel puree has a relatively low protein content because it is dominated by fiber and carbohydrates (Henríquez et al., 2010). In contrast, sorghum flour is known to have a protein content of around 10–11% (Suarni, 2017). Therefore, substitution of sorghum flour with apple peel puree causes a decrease in the total nitrogen source in the dough, so that the protein content of sorghum noodles decreases significantly, which is also supported by the results of the analysis of variance (ANSIRA) which shows a very significant effect between treatments.

Crude Fiber Content

apple skin *puree* sorghum noodles can be seen in Table 2

Table 2. Average results of crude fiber content of sorghum noodles with apple skin puree

Treatment Code	Test			Total %	Average %
	1	2	3		
S1P1	1.74	1.42	1.38	4.54	1.51 ^a
S2P2	1.85	2.01	1.98	5.84	1.95 ^b
S3P3	2.44	2.23	2.05	6.72	2.24 ^b
S4P4	2.81	2.73	2.52	8.06	2.69 ^c
KK value = 7.83%					

The table shows that the addition of sorghum flour and apple peel puree significantly affected the crude fiber content of sorghum noodles. Treatment S1P1 (90:10) produced the lowest fiber content of 1.51%, while treatment S4P4 (50:50) produced the highest fiber content of 2.69%. A consistent trend of increasing crude fiber content was observed as the concentration of apple peel puree increased and the proportion of sorghum flour decreased. This increase was due to the high dietary fiber content of apple peel, especially insoluble fiber (cellulose) and soluble fiber (pectin), which were higher than those in sorghum flour (Gorinstein et al., 2001). These results are in line with research by Sudha et al. (2007) which stated that the gradual addition of apple residue-based ingredients significantly increased the crude fiber content of processed flour products. Thus, the higher the concentration of apple peel puree, the higher the crude fiber content of sorghum noodles.

Flexibility Test

The results of the determination of the flexibility test on sorghum noodles with apple skin *puree* can be seen in Table 3.

Table 3. Average results of the flexibility test of sorghum noodles and apple skin puree

Treatment Code	Test			Total %	Average %
	1	2	3		
S1P1	0.860	0.834	0.836	2.53	0.84 ^a
S2P2	0.828	0.857	0.802	2.49	0.83 ^a
S3P3	0.787	0.798	0.759	2.34	0.78 ^b
S4P4	0.750	0.836	0.791	2.38	0.79 ^b
KK value = 3.89					

The table shows that the addition of sorghum flour and apple peel did not significantly affect the elasticity of sorghum noodles, with mean values ranging from 0.78–0.84 N and the same letter notation across all treatments. Although not statistically significant, there was a tendency for treatments with a higher proportion of sorghum flour (S1P1) to produce slightly higher elasticity than treatments with a larger addition of apple peel. This lack of difference is thought to be due to the relatively similar physical properties of sorghum flour and apple peel and the absence of gluten, resulting in a uniform noodle matrix structure across all treatments (Sudha et al., 2007). In addition, the high fiber content of apple peel has a high water-binding capacity but does not form an elastic gel like starch, thus inhibiting starch gelatinization and reducing noodle elasticity at high concentrations (Chen et al., 2011).

2. Organoleptic Test

Color

Color is a key visual attribute that influences initial consumer acceptance. According to SNI 2987:2015, the ideal color for wet noodles is the characteristic color of the raw material and should not deviate. Organoleptic test results showed that treatment S1P1 had the highest color preference score, with a score of 4.29 (like), while treatment S4P4 had the lowest score, at 2.91 (neutral).

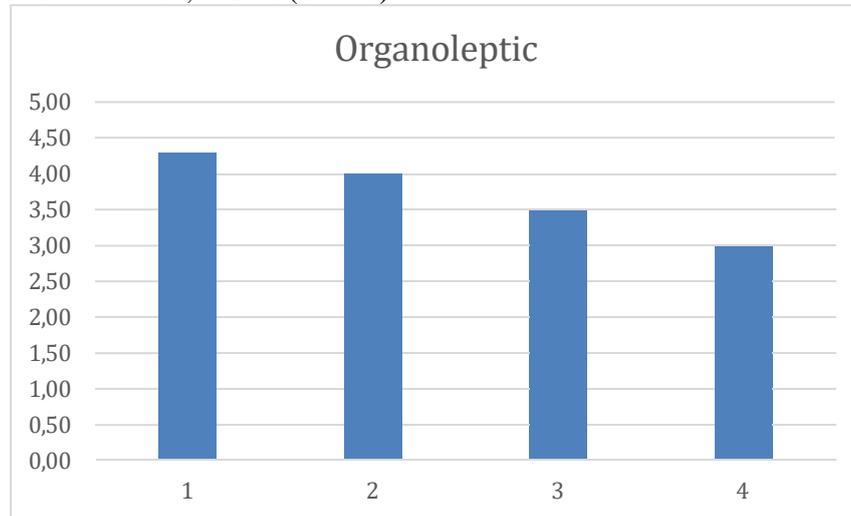


Figure 1. Histogram of Organoleptic Color Test

Based on Figure 1, treatment S1P1 obtained the highest color preference score of 4.29 and was considered most in accordance with normal color standards because it displayed the bright natural brown color typical of sorghum. In contrast, treatment S4P4 showed the lowest score of 2.91 due to the noodle color being too dark and dull, which was caused by the enzymatic browning reaction of phenolic compounds in apple skin. This is in line with research by Wandoko (2024) which stated that the visual characteristics of a product are greatly influenced by the composition of its constituent ingredients. The results of the Kruskal–Wallis test showed a significance value of 0.000 (<0.05), which indicates that variations in the addition of sorghum flour and apple skin significantly affected the level of color preference of sorghum noodles.

Aroma

Based on SNI 2987:2015, the quality requirements for the aroma of wet noodles are normal (no foreign, rancid or sour smell).

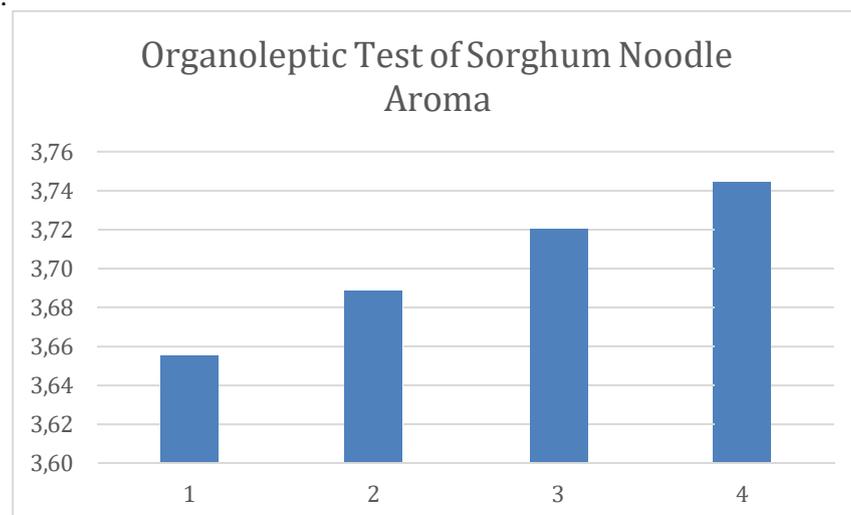


Figure 2. Histogram of Aroma Organoleptic Test

Based on Figure 2, all sorghum noodle samples obtained aroma preference scores between 3.66–3.74 which are included in the *like category*, indicating that the aroma of sorghum noodles with the addition of apple

peel puree was well accepted by the panelists and has met the SNI 2987:2015 standard. The Kruskal–Wallis test results showed a significance value of 0.897 (>0.05), which indicates that the variation in the addition of sorghum flour and apple peel puree had no significant effect on the level of aroma preference. However, descriptively, there was a tendency for an increase in scores in the treatment with the highest concentration of apple peel puree (S4P4), which is thought to be because the fruity aroma of apple peel is able to mask the typical unpleasant aroma of sorghum originating from phenolic compounds and lipoxygenase activity (Afify et al., 2012). Apple peel contains aromatic volatile compounds such as esters and aldehydes that provide a fresh and sweet aroma, thereby increasing the acceptance of the aroma of the final product (Henríquez et al., 2010).

Flavor

Taste is a crucial factor in product acceptance. According to SNI 2987:2015, the taste of noodles should be normal, typical of noodles, without any foreign or bitter aftertaste. According to the appendix, treatments S1P1 and S2P2 were the most preferred by panelists. The average taste of sorghum noodles with apple skin puree can be seen in the image below.

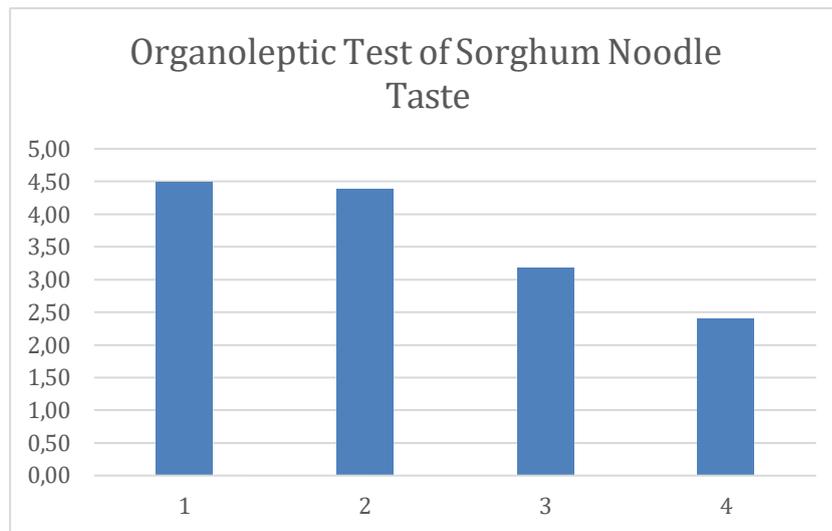


Figure 3. Histogram of Organoleptic Taste Test

Based on the results of the Kruskal–Wallis test, a significance value of 0.000 (<0.05) was obtained, indicating a very significant effect between treatments on the taste of sorghum noodles. Treatments S1P1 and S2P2 obtained scores above 4 (*like*) and were considered to meet normal taste standards according to SNI 2987:2015. In contrast, treatment S4P4 showed a significant decrease in the level of liking with a score of 2.41 (*dislike*), due to the emergence of a dominant astringent and bitter taste. This decrease was caused by the high content of phenolic compounds and tannins in apple skin which are astringent, resulting in astringent and off-flavor sensations that interfere with the acceptance of the product's taste (Wolfe et al., 2003; Lesschaeve & Noble, 2005).

Elasticity

According to general standards and SNI 2987:2015, good noodle elasticity is sufficient and not easily broken (normal). Based on the appendix, treatment S1P1 is the treatment most preferred by panelists. The average elasticity of sorghum noodles with apple skin puree can be seen in the image below.

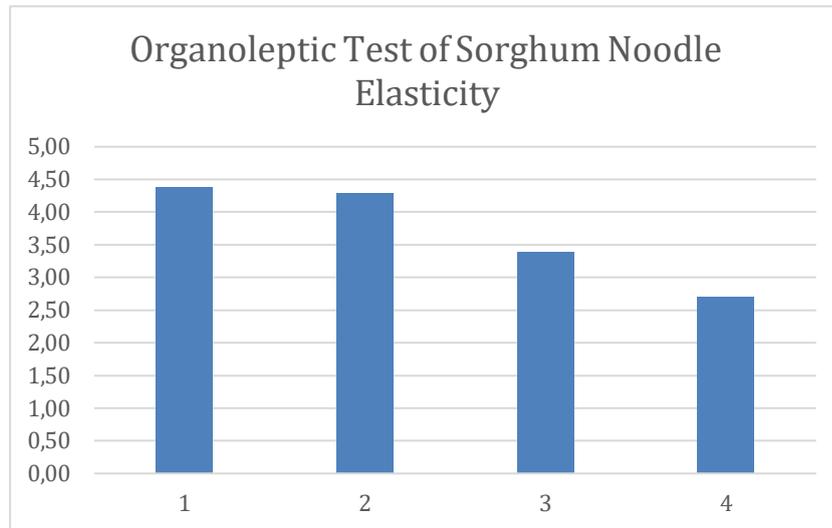


Figure 3. Histogram of Organoleptic Test of Elasticity

Based on Figure 3, the S1P1 treatment (90% sorghum: 10% apple peel) obtained the highest preference score for flexibility of 4.39 (*like*) and was considered closest to the standard for wet noodle flexibility according to SNI 2987:2015. This high score was due to the dominance of sorghum starch which was able to undergo optimal gelatinization, thus forming a chewy and cohesive noodle structure. In contrast, the S4P4 treatment showed the lowest score of 2.71 due to the brittle and less flexible noodle texture, in line with the results of the physical flexibility test. This decrease in flexibility quality was caused by the high content of insoluble fiber in apple peel which inhibited starch gelatinization and weakened the noodle matrix due to competition for water absorption and the effect of fiber filler in the dough structure (Aravind et al., 2012; Masoodi & Chauhan, 2007). This finding supports the statement of Permana et al. (2015) that increasing fiber content tends to decrease flexibility and increase fragility of food products.

3. Determining the Best Treatment

Effectiveness testing was used to determine the best and preferred treatment (de Garmo , 1984). Based on the results of the effectiveness test on all research parameters, including physicochemical and organoleptic tests, it was shown that the best treatment obtained the highest yield value (NH). The average NH for all research parameters in the effectiveness test can be seen in Table 4.

Table 4. Effectiveness test Yield Value (NH) of Treatment

Parameter	Weight	S1P1	S2P2	S3P3	S4P4
Protein	9	0.15	0.03	0.02	0.0
Fiber	9	0.00	0.06	0.09	0.2
Attractiveness	9	0.15	0.13	0.00	0.0
Forest	7	0.12	0.10	0.05	0.0
Aroma	8	0.00	0.05	0.10	0.1
Flavor	9	0.15	0.14	0.06	0.0
Texture	9	0.15	0.14	0.06	0.0
Total	60	0.72*	0.64	0.37	0.30

Based on the determination of the effectiveness test on all research parameters can be seen in Table 4.6, where the best treatment is the treatment with the highest yield value (NH), namely in treatment S1P1 (90% sorghum flour: 10% apple skin puree) with an NH value of 0.72% with parameter criteria being protein content of

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10.42%, crude fiber content of 1.51%, and flexibility of 0.84, for organoleptic color 4.29 (Like), Aroma 3.66 (Like), Taste 4.49 (Like), and Texture 4.39 (Like).

CONCLUSION

Based on the results of research and data analysis regarding the effect of adding sorghum flour and apple peel *puree* on the physicochemical and organoleptic quality of gluten-free wet noodles, it can be concluded that variations in the proportion of the two ingredients have a very significant effect ($p < 0.01$) on protein content, crude fiber content, and the level of organoleptic preference on color, taste, and texture parameters. However, this treatment did not have a significant effect ($p > 0.05$) on the physical properties of flexibility (tensile strength) and the level of organoleptic preference on aroma parameters. Based on the results of the effectiveness test, the best treatment was obtained in the S1P1 formulation with a ratio of 90% sorghum flour and 10% apple peel *puree* which produced the highest Yield Value (NH) of 0.72, with product characteristics in the form of a protein content of 10.42%, a crude fiber content of 1.51%, a flexibility value of 0.84 N, and an organoleptic preference level that was classified as preferred in all parameters, namely color 4.29, aroma 3.66, taste 4.49, and texture 4.39.

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