AgriHealth Journal of Agri-food, Nutrition and Public Health
ISSN 2722-0656 (Print) 2722-0648 (Online)
AgriHealth: Journal of Agri-food, Nutrition and Public Health. 4(2), 131-140, 2023
URL: https://jurnal.uns.ac.id/agrihealth/article/view/78427
DOI: http://dx.doi.org/10.20961/agrihealth.v4i2.78427

Sensory Evaluation of Gluten-Free Wet Noodles Made from Potato (*Solanum tuberosum* L.) Flour with the Addition of Kersen (*Muntingia calabura* L.) Leaves Powder

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Received: August 31, 2023; **Accepted**: October 3, 2023

Abstract

Gluten-free noodles are a processed food that has become an alternative food for gluten-intolerant patients. This study investigated the effect of gluten-free wet noodles made from potato flour and tapioca starch (T1 = 40:60%, T2 = 50:50% and T3 = 60:40%) and its addition of kersen leaves powder (K1 = 5%, K2 = 10% and K3 = 15%) on consumer acceptability using hedonic and descriptive tests with color, aroma, taste and texture attributes involved 25 semi-trained panelists. The results showed that there was a significant difference ($p < 0.05$) in the level of consumer preference for color and texture and no significant difference ($p > 0.05$) in aroma and taste. The preferred formulations in terms of color were T1K3, which contained 40% potato flour and 60% tapioca starch with 15% kersen leaves powder, and T2K3, which included 50% potato flour and 50% tapioca starch with 15% kersen leaves powder. T2K3 was also preferred for aroma attributes, while T1K1, for taste attributes, contained 40% potato flour and 60% tapioca starch with 5% kersen leaves powder. T1K2 was preferred for texture attributes, which included 40% potato flour and 60% tapioca starch with 10% kersen leaves powder. Hedonic descriptive testing results showed significant differences for all formulations for each attribute. The current study's findings indicated that the T1K2 formulation consisting of 40% potato flour and about 60% tapioca starch with 10% kersen leaves powder got the highest score on hedonic tests based on the results from all attributes.

Keywords: flavor; gluten-free noodles; sensory attributes

INTRODUCTION

Noodles are an alternative food product that is quite popular among people. Three types of noodles are marketed in Southeast Asia: instant, wet and dry. The consumption rate of wet noodles in Southeast Asia is only 20% and this condition is due to the shelf life of wet noodles being only around 1 to 2 days. Therefore, people tend to choose instant or dry noodles (Kingwell et al., 2019). Based on Indonesian Food Composition Data (Ministry of Health, 2018), the nutritional content of 100 g of wet noodles is 80 g of water, 0.6 g of protein, 3.3 g of fat, 14 g of carbohydrates and 0.1 g of fiber. Most noodles on the market are made from wheat flour with a minimum content of 24% wet gluten and 8% dry gluten (Kaushik et al., 2015), resulting in noodles with a soft and elastic texture (Azkia et al., 2020). Higher gluten content in noodles causes their consumption to be less safe for celiac patients who have gluten intolerance (Tamai and Ihara, 2023). Gluten intolerance is a medical condition portrayed by sensitivity to the gluten proteins in wheat, barley and rye (Tanveer and Ahmed, 2019). In addition, excessive gluten consumption can

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Cite this as: Kusumasari, F. C., Handayani, A. M., Setyowati, L., & Satya, M. C. N. (2023). Sensory Evaluation of Gluten-Free Wet Noodles Made from Potato (*Solanum tuberosum* L.) Flour with the Addition of Kersen (*Muntingia calabura* L.) Leaves Powder. *AgriHealth: Journal of Agri-food, Nutrition and Public Health*, *4*(2), 131-140. doi: http://dx.doi.org/10.20961/agrihealth.v4i2.78427

negatively impact health (Behrendt et al., 2021). Thus, consuming gluten-free foods has become a lifestyle among the public (Bastiawan et al., 2022).

Potato (*Solanum tuberosum* L.) is an agricultural commodity with abundant production. Potato production in Indonesia in 2022 reached 1.5 million tons with an increase of 9.5% compared to 2021 (Statistic Indonesia, 2023). Potatoes contain various nutrients the body needs, including starch, dietary fiber, amino acids, minerals, vitamins and phenolic compounds (Sheikh et al., 2021). Thus, potatoes are widely used as a substitute for wheat flour in various preparations, including making wet noodles. Research conducted by Pu et al. (2017) showed that the substitution of potato flour less than 40% in making wet noodles produced noodles with the best acceptability even though the substitution of potatoes in making noodles can reduce the sensory characteristics and physical properties of wet noodles.

Kersen (*Muntingia calabura* L.) is a tropical plant that is used as a shade plant. The ethanol extract of kersen leaves contains secondary metabolite compounds such as flavonoids, alkaloids, terpenoids, tannins and saponins (Handayani et al., 2021; Rakhmadevi et al., 2021). These compounds have the ability as antioxidants (Puspitasari et al., 2017; Azizah et al., 2020), antibacterial (Handayani, 2015), anti-inflammatory (Rahman et al., 2017) and antihyperlipidemia (Puspasari et al., 2016). Research conducted by Bait et al. (2021) showed that the addition of kersen leaves extract to rice can increase the nutritional content and functional properties of the rice.

Potatoes and kersen leaves can be an alternative material to make gluten-free noodles with many benefits for health. Gluten-free noodles made from potato flour contain more rapidly digestible starch, which helps to create a feeling of fullness and produces a low blood sugar response in consumers (Yang et al., 2023). Adding kersen leaves powder can enrich the nutritional content of gluten-free noodles (Ariani et al., 2023). However, research on gluten-free noodles made from potato flour with the addition of kersen leaves powder has never been done. Therefore, this study aimed to make gluten-free wet noodles using potato flour and tapioca starch with the addition of kersen leaves powder and also evaluate the sensory attributes, including color, aroma, taste and texture. It is essential to assess consumer acceptance besides its nutrition content to ensure the product that has been developed can be accepted by the community.

MATERIALS AND METHOD

Material

The materials used in this study were potato flour, tapioca starch, carboxy methyl cellulose (CMC) (“Koepoe Koepoe”), salt and eggs bought from the market in Jember. Kersen leaves were obtained from trees planted around Politeknik Negeri Jember.

Experimental design

This study used a completely randomized design (CRD) with two factors. The first factor was the potato flour and tapioca starch ratio, and the second was the addition of kersen leaves powder. There were three treatment levels of potato flour:tapioca starch ratio (40:60%, 50:50% and 60:40%) based on Effendi et al. (2016) with modifications and three treatment levels of kersen leaves powder (5%, 10% and 15%) resulted in 9 experimental units.

Production of kersen leaves powder

Kersen leaves powder was prepared according to the method described by Handayani et al. (2021). Kersen leaves obtained were sorted to get clean and old leaves, then dried using a food dehydrator. After drying, the kersen leaves were ground and sieved using a 100-mesh sieved to get the powder.

Preparation of wet noodles

All ingredients were weighed according to the composition in Table 1. The wet noodles were prepared based on the procedure described

Table 1. Experimental design

Ratio of potato flour and tapioca starch	Addition of kersen leaves powder		
	K1 (5%)	K2 (10%)	K3 (15%)
T1 (40:60%)	T1K1	T1K2	T1K3
T2 (50:50%)	T2K1	T2K2	T2K3
T3 (60:40%)	T3K1	T3K2	T3K3

by Effendi et al. (2016) with modifications. All the powder ingredients were mixed well. Then the loose beaten egg was added slowly until the dough could be molded. The dough was divided into several parts and made into sheets with a thickness of ±1.5 mm. After that, the noodles were developed using a noodle maker and boiled for ±5 minutes at 100 °C.

Sensory evaluation

Sensory evaluation was divided into two types. The first evaluation was the hedonic test, which was conducted by scoring the color, aroma, taste and texture of the wet noodles with a score of 1 to 5 (dislike extremely, dislike slightly, neither like nor dislike, like slightly and like extremely) based on the method described by Purwandari et al. (2014) with modification. The second evaluation was the descriptive test to recognize and measure the product. Product's sensory attributes were specified to get desired information about the parameters, which could be seen in Table 2 with a score of 1 to 5 for each parameter (Agustina et al., 2021). The test involved 25 semi-trained panelists.

Data analysis

The data obtained were analyzed using the one-way ANOVA method followed by DMRT if there were differences at the significance level $\alpha = 5\%$. The analysis used SPSS 25.0 software.

RESULTS AND DISCUSSION

Gluten-free noodles are made without wheat flour in their formulation (Winarti et al., 2018). Gluten is a protein in wheat grains that makes the dough elastic and chewy (Kumalasari et al., 2018). The sensory evaluation involved 25 semi-trained panelists to determine the consumer acceptance of the wet noodles. Based on Figure 1, it could be seen that the panelists' preferences for color attributes were T1K3 and T2K3 formulation. T1K3 was the formulation with the lowest composition of potato flour compared to tapioca starch (40:60%) and 15% of kersen leaves powder. At the same time, the ratio of potato flour and tapioca starch in T2K3 was 50:50% and 15% of kersen leaves powder. Panelists preferred the darker color of the noodles because of the addition of kersen leaves powder. Kersen leaves have natural substances such as chlorophyll that produce a green color (Huda et al., 2015). T2K3 also had the highest score for the panelists' preferences based on its aroma. Increasing the addition of kersen leaves powder could improve the intensity of the scent of kersen leaves in the noodles. The panelists' preference for taste attribute was T1K1 formulation, with the ratio of potato flour and tapioca starch was 40:60% and 5% of kersen leaves powder. As for texture attribute, panelists preferred T1K2 formulation with the ratio of potato flour and tapioca starch of 40:60% and 10% of kersen leaves powder. T1K2 was the best formulation based on the hedonic test because it got the highest average score for all parameters (color, aroma, taste and texture) (Figure 1). The highest tapioca starch (60%) in the noodle composition produced the best texture based on panelists' preference because it produced elastic noodles. Tapioca starch contains amylopectin, which contributes to the elasticity of the noodles (Winarti et al., 2018). T1K2 had 10% of kersen leaves powder that slightly produced the aroma and taste of kersen leaves based on Table 4 and 5. This result was similar to a previous study conducted by Hardiyanti et al. (2018), wherein they observed

Table 2. Descriptive test of gluten-free wet noodles

Attributes	Score
Color	
Greenish yellow	1
Yellowish green	2
Turquoise green	3
Green	4
Dark green	5
Aroma of kersen leaves	
No smell	1
Slightly smell	2
Moderately smell	3
Very strong smell	4
Extremely smell	5
Taste of kersen leaves	
No taste	1
Slightly taste	2
Moderately taste	3
Very taste	4
Extremely taste	5
Texture	
Not chewy	1
Slightly elastic	2
Moderately elastic	3
Very elastic	4
Extremely elastic	5

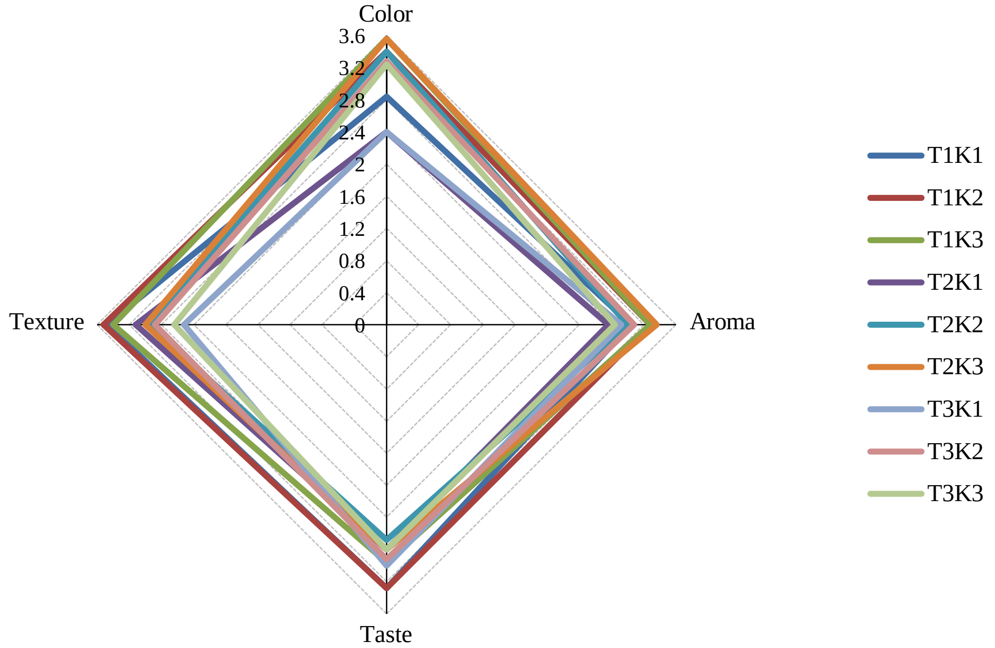

Figure 1. Spider graph of gluten-free wet noodles' hedonic test

that increasing kersen leaves extract concentration in marshmallow production decreased the panelists' preferences for the aroma and taste of marshmallows because the aroma and taste of kersen leaves extract were too strong.

Color

Color is the first parameter that influences consumer preferences because color is a visualization of a product (Tarwendah, 2017). Based on ANOVA analysis, the formulation of gluten-free wet noodles using potato flour as the base material with the addition of kersen leaves powder had a significant effect on the level of panelists' preference for the product color with a significance value $p < 0.05$. The results of the descriptive test also showed significant differences in each formulation. The color of wet noodles came from the addition of kersen leaves powder.

Based on Table 3, the highest value of the hedonic test in the color parameter was 3.56, found in the T1K3 formulation, with the composition of 40:60% (potato flour:tapioca starch) and the addition of 15% kersen leaves powder. T2K3 formulation also got the same value with the composition of 50:50% (potato flour:tapioca starch) with the addition of 15% kersen leaves powder. The descriptive test value in the T1K3 formulation was 4.60 and 4.04 for the T2K3 formulation. Based on descriptive test parameters, both values were in the green to dark green color category. It could be seen that panelists preferred noodles with colors that tended to be dark due to the addition of 15% kersen

Table 3. The value of sensory evaluation for color parameter

Formulation	Hedonic test	Descriptive test
T1K1	$2.84{\pm}0.98^{ab}$	$2.36{\pm}0.95^{b}$
T1K2	$3.40{\pm}0.91^{bc}$	$3.20{\pm}0.82^{c}$
T1K3	$3.56{\pm}1.08^{c}$	$4.60{\pm}0.65^{e}$
T2K1	$2.40{\pm}0.87^{a}$	$1.52{\pm}0.59^{a}$
T2K2	$3.40{\pm}0.96^{bc}$	$3.20{\pm}0.79^{c}$
T2K3	$3.56{\pm}1.04^{c}$	$4.04{\pm}0.79^{d}$
T3K1	$2.40{\pm}1.00^{a}$	$1.44{\pm}0.58^{a}$
T3K2	$3.28{\pm}0.84^{bc}$	$3.72{\pm}1.02^{d}$
T3K3	$3.24{\pm}1.01^{bc}$	$3.76{\pm}0.97^{d}$

Note: Different superscripts showed significant differences ($p < 0.05$) based on the DMRT test

leaves powder. The descriptive test result showed that adding kersen leaves powder could increase the color intensity of wet noodles. Kersen leaves powder is dark green-black (Idrak et al., 2022). Therefore, the more kersen leaves powder added to the noodle dough, the darker the noodles' color produced. Research conducted by Anggriani et al. (2019) showed that the color of raw fish flour without adding kersen leaves extract had a lighter color intensity. The lowest hedonic test value was owned by T2K1 and T3K1 formulation with the addition of 5% kersen leaves powder with descriptive test values ranging from 1.44 to 1.52, which showed a greenish yellow to yellowish green color. The resulting color tended to be pale, thus reducing consumer preference.

Aroma

Aroma is a parameter used to determine the level of consumer preferences after color parameters. Color is an attribute defined visually, while aroma is determined using the sense of smell (Lamusu, 2018). Aroma is produced from volatile compounds in food and received by human olfactory receptors (Tarwendah, 2017). The ANOVA showed that the gluten-free noodle formulation with the addition of kersen leaves powder did not give a significant difference in panelists' preference for the aroma of the noodles. On the other hand, DMRT was not carried out. However, the results of the descriptive test showed a significant difference in the aroma of wet noodles for each formulation with a significance value of $p < 0.05$. The aroma of wet noodles comes from the compounds contained in kersen leaves.

Based on Table 4, the highest hedonic test value for the aroma parameter was found in the T2K3 formulation with a composition of 50:50% (potato flour:tapioca starch) and the addition of 15% kersen leaves powder. The descriptive test value of the T2K3 formulation was 3.24, producing noodles with a moderate to very strong smell of kersen leaves. Kersen leaves contain flavonoids, tannins and alkaloid compounds that give a distinctive aroma to wet noodles (Ahmad et al., 2018; Walalangi et al., 2020). Based on the descriptive test for the different amounts of kersen leaves powder in Table 4, the higher the number of kersen leaves powder added to the noodles, the stronger the smell of kersen leaves. It was caused by the increasing concentration of flavonoids, tannins and alkaloid compounds in the noodles that contribute to the aroma. This finding was in line with research conducted by Huda et al. (2015), which stated that the greater the amount of kersen leaves extract used in jelly candy, the more panelists liked the smell of the jelly candy. The lowest hedonic test value was found in the T2K1 formulation with a composition of 50:50% (potato flour:tapioca starch) and the addition of 5% kersen leaves powder. It had a slight to moderate smell of kersen leaves based on a descriptive test with a value of 2.44. Reducing the aroma of kersen leaves would decrease consumer preference for wet noodles.

Taste

Taste is one of the essential attributes to determine whether a product is acceptable to consumers (Lamusu, 2018). The ANOVA showed no significant effect of gluten-free wet noodle formulations with the addition of kersen leaves on consumer preference. Therefore, DMRT was not carried out. However, the results of the descriptive test provided a significant difference in the taste of wet noodles for each formulation with a significance value of $p < 0.05$. The taste was influenced by the amount of kersen leaves powder added to the noodle dough.

Table 4. The value of sensory evaluation for aroma parameter

Formulation	Hedonic test	Descriptive test
T1K1	3.04±0.93	2.60±0.71^{abc}
T1K2	3.28±0.94	2.64±0.95^{abcd}
T1K3	3.28±0.79	3.12±0.88^{def}
T2K1	2.76±0.97	2.44±0.87^{ab}
T2K2	3.00±0.91	2.92±0.91^{bcde}
T2K3	3.36±0.81	3.24±1.13^{ef}
T3K1	2.92±0.81	2.28±0.84^{a}
T3K2	3.08±0.81	2.60±0.71^{abc}
T3K3	2.84±0.69	2.64±0.95^{abcd}

Note: Different superscripts showed significant differences ($p < 0.05$) based on the DMRT test

Table 5. The value of sensory evaluation for taste parameter

Formulation	Hedonic test	Descriptive test
T1K1	3.28±0.84	2.76±0.72[cd]
T1K2	3.28±0.79	2.56±1.08[bc]
T1K3	2.96±0.89	3.40±1.04[ef]
T2K1	2.80±1.12	2.12±0.97[ab]
T2K2	2.68±0.75	3.40±0.91[ef]
T2K3	2.80±0.82	3.00±0.96[cde]
T3K1	3.00±0.96	2.00±0.76[a]
T3K2	2.92±0.70	3.12±0.93[de]
T3K3	2.80±0.91	3.68±0.85[f]

Note: Different superscripts showed significant differences ($p < 0.05$) based on the DMRT test

Based on Table 5, the highest hedonic test value was found in the T1K1 formulation with a composition of 40:60% (potato flour:tapioca starch) and the addition of 5% kersen leaves powder. T1K2 had the same composition as T1K1 with the addition of 10% kersen leaves powder. The result of the descriptive test in T1K1 was 2.76 and 2.56 for T1K2, which showed slightly to moderately tasted kersen leaves in the wet noodles. Kersen leaves powder has an astringent taste from tannin compounds (Febriani et al., 2015) and a bitter taste from alkaloid compounds (Laswati et al., 2017). The T3K3 formulation with 15% kersen leaves powder addition had the highest descriptive test value with moderate to very tasted of kersen leaves. The descriptive test showed that the more kersen leaves powder added to the noodles, the stronger the taste of kersen leaves because of the increasing number of tannins and alkaloids. Research conducted by Wangi et al. (2022) showed that the more kersen leaf extract used in stick production, the bitterer the sticks tasted. The lowest hedonic test value was found in the T2K2 formulation with a moderate taste of kersen leaves.

Texture

Texture is one of the physical parameters used to determine the acceptability of noodle products (Asmoro et al., 2017). The ANOVA showed a significant effect of gluten-free wet noodles on the texture attributes with a significance value of $p < 0.05$. The results of the descriptive test also provided significant differences in the texture of the wet noodles produced for each formulation. The texture of the noodles is influenced by the physical characteristics and composition of the flour used (Yulianti and Kanetro, 2018).

Based on Table 6, the highest value of the hedonic test was T1K2 formulation with a composition of 40:60% (potato flour:tapioca starch) and the addition of 10% kersen leaves powder. The descriptive test value was 3.36, indicating that the sample provides a moderate to very elastic texture. Amylopectin is a component that contributes to the elastic properties of noodles (Winarti et al., 2018). Amylopectin can increase viscosity, making the resulting gel’s consistency harder and stickier. Therefore, it will produce noodles with denser and more elastic properties (Handajani and Pangesthi, 2019). Tapioca starch

Table 6. The value of sensory evaluation for texture parameter

Formulation	Hedonic test	Descriptive test
T1K1	3.48±1.12[bc]	3.52±1.05[d]
T1K2	3.52±1.00[c]	3.36±0.86[cd]
T1K3	3.40±0.96[bc]	2.96±1.06[bc]
T2K1	3.12±1.05[abc]	2.96±1.02[bc]
T2K2	2.96±1.10[abc]	2.92±1.00[bc]
T2K3	3.00±0.76[abc]	2.68±0.95[ab]
T3K1	2.52±0.92[a]	2.28±1.14[a]
T3K2	2.88±1.09[ab]	2.92±0.91[bc]
T3K3	2.64±1.11[a]	2.68±1.14[ab]

Note: Different superscripts showed significant differences ($p < 0.05$) based on the DMRT test

contains higher amylopectin than potato flour (Ahmed et al., 2016). The amylopectin content of tapioca starch is 83% (Alfani et al., 2019), while potato flour only has 76.9% (Arumsari et al., 2014). Decreasing the amount of tapioca composition will reduce the elasticity of the noodles. The lowest hedonic test was found in the T3K3 formulation, which had 60:40% (potato flour:tapioca starch) composition and 15% kersen leaves powder. Its descriptive test value was 2.68, with a slightly to moderate elastic texture. It was in line with research conducted by Patty et al. (2023), which showed that as the amount of sago flour with 73% of amylopectin in dried noodle formulation increases, it caused an increase in the elongation value. Elongation value is used to evaluate the degree of elasticity and flexibility.

CONCLUSIONS

Gluten-free wet noodles made from potato starch with the addition of kersen leaves powder had a significant effect on the consumer preference for color and texture but no significant effect on aroma and taste. The gluten-free wet noodle formulation preferred by panelists from color attribute was T1K3 contained 40% potato flour and 60% tapioca starch with 15% kersen leaves powder, and T2K3 had 50% potato flour and 50% tapioca starch with 15% kersen leaves powder which produced green-dark green color, the panelists also chose T2K3 for aroma attributes which had noodles with a moderate to very strong smell of kersen leaves, for taste was T1K1 which contained 40% potato flour and 60% tapioca starch with 5% kersen leaves powder that had slightly to moderate tasted kersen leaves and for texture was T1K2 formulation which consisted of 40% potato flour and 60% tapioca starch with 10% kersen leaves powder that had a moderate to very elastic texture. According to the panelists, T1K2 formulation became the preferred formulation based on the results' accumulation from all attributes.

ACKNOWLEDGEMENTS

Authors want to express their gratitude to Politeknik Negeri Jember, who has provided funding for the Research and Community Service program from PNBP funding source budget year 2023 with contract number 897/PL17.4/PG/2023.

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