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FULL PAPER

Gluten-free noodles made based on germinated organic red rice: chemical composition, bioactive compounds, antioxidant activity and sensory evaluation

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Abstract

The purpose of this research was to find out the chemical composition, bioactive compound content, antioxidant activity, and sensory evaluation of gluten-free noodles made from organic red rice. The study was carried out by creating three formulations using germinated organic red rice flour, germinated *Vigna radiata* flour, and tapioca flour. Proximate analysis, resistant starch and dietary fibre were used to analyze the chemical composition. Phenolic and flavonoid compounds were among the bioactive compounds studied. The DPPH method was used to assess antioxidant activity. The findings revealed that all three formulations of gluten-free organic red rice noodles, formulations I, II, and III, had high fibre content, resistant starch, bioactive compounds, and antioxidant activity. According to sensory evaluation, gluten-free organic red rice noodles formulation I have the highest acceptance rate compared to organic red rice noodles formulations II and III. The amount of soluble dietary fibre was 0.79±0.08%, the amount of insoluble dietary fibre was 6.73±0.18%, and the amount of resistant starch was 7.56±0.02%. Total phenolics content (TPC) was 49.16±0.27%, total flavonoids content (TFC) was 53.36±0.86%, and the IC_{50} was 9665.84±72.39. The content of bioactive compounds and the IC_{50} of gluten-free organic red rice noodles have a significant and positive correlation. According to the study's findings, gluten-free organic red rice noodle formulation could be developed as a functional food high in dietary fibre, resistant starch, and antioxidants.

1. Introduction

Data from Basic Health Research in Indonesia in 2018 show an increase in the prevalence of degenerative diseases that become comorbid covid-19 diseases, indicating the need to reduce the risk of this disease (Kemenkes, 2018). The strategy of changing the diet can inhibit the onset of inflammation that causes oxidative stress, thus maintaining good health and reducing the risk of serious degenerative diseases. Foods high in protein, lipids, carbohydrates, dietary fibre, resistant starch, bioactive compounds, and antioxidants are recommended for preventing and managing degenerative diseases that are also comorbid with Covid-19 (Arshad *et al.,* 2020; De Faria Coelho-Ravagnani *et al.*, 2020; Lange and Nakamura, 2020; Zabetakis *et al.,* 2020).

Organic red rice is a popular local food in Indonesia. Organic rice, which has a registered number with the agriculture department, is one of the organic red rice varieties developed. The benefit of organic red rice is that it is high in bioactive compounds, fibre, and antioxidants. The disadvantage is that it contains phytic acid, which reduces the bioavailability of some minerals (Kumar *et al.,* 2010). To reduce the level of phytic acid, the germinating process is required. Green beans have the advantage of being high in amylose, protein, fibre, and bioactive compounds. The disadvantages are anti-nutritional compounds. The germination process can mitigate this weakness.

Increased health awareness influences the growing demand for non-gluten products and products with functional properties for the body, resulting from the growing number of celiac patients and consumption trends to eliminate allergenic proteins from the diet (Gao *et al.,* 2018). According to research, the development of functional foods should take preference into account. Functional foods are intended to lower the risk of certain degenerative diseases, such as high blood pressure, cholesterol, and blood sugar (Kaur and Das, 2011). The development of functional foods is facilitated when the community supports the product and positively impacts health (Siro *et al*., 2008). Noodles are a popular food that is enjoyed and consumed by most of the world's

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population, including Indonesia, which ranks second in the world in noodle consumption (Khairiyyah, 2020).

The demand for functional foods (gluten-free products) grows in tandem with increased health awareness, the diagnosis of coeliac disease, gluten allergy, and non-celiac sensitivity, as well as the advancement of science and technology to the point where the general public can accept products (Heller, 2009; Balakireva and Zamyatnin, 2016). Consuming functional and healthy foods raises awareness of their ability to prevent and reduce the occurrence of degenerative diseases. Furthermore, the accuracy of functional food formulations can increase dietary fibre intake, bioactive compounds, resistant starch, and proteins, making it one of the solutions to reduce the risk of degenerative diseases (Daliu *et al.,* 2019).

The development of gluten-free noodles can result in well-accepted noodles by the community and have the benefits of being high in fibre, resistant starch type 3 (RS3), bioactive compounds, and antioxidants. It has the potential to be used as a functional food to lower the risk of degenerative diseases. The strategy for meeting the gluten-free noodles set specifications is to make changes to the constituent ingredients, specifically the germination of red rice and green beans. Rice flour is used to produce gluten-free noodles (Heo *et al*., 2013; Kim *et al.,* 2014). Rice flour is thought to be the best wheat flour substitute because it tastes bland, has high digestibility, and starch granules can form the characteristic texture of noodles. On the negative side, the glycemic load is quite high, as is the phytic acid content (Boers *et al.,* 2015), which the germination process can reduce. Organic red rice germination can reduce phytic acid levels while increasing bioactive compounds and increasing antioxidant activity (Islam *et al.,* 2021.; Müller *et al.,* 2021), anti-diabetes (Boue *et al.,* 2016), and anti-hypercholesterolemia (Salgado *et al.,* 2010).

Steaming, extrusion, boiling, cooling, and drying gluten-free noodles can raise RS3 noodle levels (Yadav *et al.,* 2009). Food containing RS3 can be anti-inflammatory, antidiabetic, and immune-boosting (Higgins and Brown, 2013; Sun *et al.,* 2018). Combining germinated organic red rice, germinated *Vigna radiata*, sago starch and tapioca flour to make gluten-free noodles as functional foods requires the proper process and formulation. As a result, based on local potential, it is expected to produce gluten-free noodles as a functional food. This research aimed to find out the chemical composition, bioactive compounds, antioxidant activity, and sensory evaluation of gluten-free organic red rice noodles.

2. Materials and methods

2.1 Vigna radiata and organic red rice germination

The germination of *Vigna radiata* takes 36 hrs. Mung bean seeds were washed under running water and soaked for 12 hrs at room temperature. Seeds were placed in a sprouter after the excess water was removed. Then it was folded, clothed, and stored in a dark place. Every 12 hrs, the mung bean is moistened with running water, after a 36-hour sprouting process (Guo *et al.,* 2012). *Vigna radiata* sprouts were dried in a cabinet drier at 50°C for 24 hrs. The milling and sieving process follows, with the Sieve Tyler Mesh 80 being used. Organic red rice germination was carried out in a dark room at room temperature. The organic red rice to water ratio was 1:10 (w/v). The soak time was 12 hrs. The germination times were 36 hrs. Every 12 hrs, organic red rice was watered with running water (Lee *et al.,* 2013). Organic red rice germinated in a drier cabinet for 12 hrs at 40°C. After that, the dried organic red rice or dried *Vigna radiata* was ground and sifted through a Tyler mesh 80 sieves.

2.2 Gluten-free organic red rice noodle formulation

Germinated organic red rice flour (55%, 60%, 65%), white rice flour (10%, 5%, 0%), sago starch (10%), tapioca flour (20%), and germinated *Vigna radiata* flour are the ingredients used to make gluten-free organic red rice noodles. Gelatinizing tapioca flour was used in the manufacturing process. Tapioca flour and water are mixed in a 3:2 (b/v) ratio. The tapioca flour and water mixture was then heated to form a clear gel. Then, organic red rice flour and *Vigna radiate* flour are combined and stirred until a dough forms. The dough was then passed through a roller (noodle maker) to form a sheet. The sheet was cut into a specific noodle shape, steamed for 50 mins until all parts of the noodles were gelatinized, and dried for 6 hrs in a cabinet drier. Finally, the noodles were wrapped in plastic until further examination.

2.3 Chemical composition analysis

Proximate analysis, which included moisture content, ash content, fat, protein, and dietary fibre, was carried out following AOAC methods (Lee *et al.*, 1992; Cunniff, 1995). The methods were used to determine the resistant starch levels (Englyst *et al.,* 1992).

2.4 Bioactive compound extraction process

Methanol was used as a solvent in the gluten-free organic red rice noodle extraction used the maceration technique. The noodle-to-solvent ratio was 1:5 (w/v). The maceration method was completed after seven days. The solution was filtered with Whatman No.1 filter paper and evaporated with a rotary evaporator after seven days to dispose of the solvent. The extracts were kept at -22°C.

2.5 Total phenolic content determination

The spectrophotometric technique was used to determine the total phenolic content (Singleton *et al.,* 1999). A total of 0.2 mL of gluten-free organic red rice noodle methanol extracts of formulations I, II, and III with a concentration of 100 mg/L, plus up to 2.5 mL of 10% Folin-Ciocalteu reagent and a pair of mL of 7.5% Na_2CO_3. The received aggregate was allowed to sit for 15 mins at 45°C. The absorbance of the solution was measured with a spectrophotometer at 765 nm. The total phenolic content was expressed in milligrams (mg) of gallic acid per hundred grams of dried extract (mg of GAE/100 g extract).

2.6 Total flavonoid content determination

The total flavonoid content was determined using spectrophotometric methods (Quettier-Deleu *et al.,* 2000). At 1000 mg/L concentrations, up to 1 mL of methanol extract was introduced at 1 mL 2% $AlCl_3$ dissolved in 50% ethanol. The incubation period was 20 mins. A vortex then homogenized the aggregate with a wavelength of 415 nm. The total flavonoid content was expressed as quercetin equivalents (mg quercetin/100 g extract).

2.7 Antioxidant activity evaluation with DPPH Method

The DPPH method was used to test antioxidant activity. (Singh *et al.,* 2009). The extracts were 0.2 mL at 1000-5000 g/mL and mixed with 2 mL of DPPH (0.1 mM in methanol solution). The solution was homogenized with Vortex, allowing for a half-hour light-protected room temperature. At a wavelength of 517 nm, the absorbance of the solution was measured. The radical scavenging activity evolved into a calculated application of the method:

$$\frac{Ao - A1}{Ao} \times 100\%$$

The absorbance of the control (without the noodle extract) was A_0, and the absorbance of the extract was A_1. The IC_{50} value was calculated using linear regression analysis and was used to indicate antioxidant capacity.

2.8 Sensory evaluation

A sensory evaluation test was performed on three different types of gluten-free organic red rice noodles and white rice noodles (control). Use a panel of 50 untrained panellists. Sensory evaluation includes flavour, colour, texture, taste, and overall—assessment scale of 1 (extremely dislike) to 9 (like extremely).

2.9 Statistical analysis

The study's findings included the average value and standard deviation from a triplicate experiment. To analyze differences, one-way ANOVA was used, followed by the least significant difference test at p 0.05. Furthermore, the correlation between total phenolics and flavonoid content components and antioxidant activity was tested using Pearson correlation bivariate using SPSS version 16.0 (SPSS Inc., South Wacker Drive, Chicago, United States of America).

3. Results and discussion

3.1 The development and formulation of gluten-free organic red rice noodle

Organic red rice has a low amylose content (18.56%), resulting in noodles with an easily broken texture. As a result, other constituent ingredients, such as tapioca flour and sago starch as an adhesive of brown rice sprout flour, are required to improve the texture of the noodles produced. Red rice sprout flour, white rice flour, tapioca flour, sago flour, *Vigna radiata* sprout flour, hydrocolloids, salt, and water make up the brown rice noodles used in this study. Each of the red rice noodles' constituent ingredients contributes to the texture of the noodles.

Water is the second most important raw material used in the production of rice noodles. Water used in flour production is typically (30–35%) to produce a good dough (Hou, 2001). Water influences the hydration of flour, gelatinization of starches, sheeting process, and noodle texture formation. Salt is also a key ingredient in the production of noodles, accounting for 1-3% of the total weight of the product. Salt plays a role in improving the properties of dough sheets, particularly those with a high water absorption index. Another function is to improve texture and taste. In addition to imparting a salty flavour, it also serves as a flavour enhancer in a variety of other foods. Salt prevents damage and oxidative reactions caused by high humidity and temperatures, thereby extending the product's shelf life. Higher salt concentrations in noodle formulations also slow drying (Fu, 2008). The use of hydrocolloids can help to improve the overall quality of noodles. Guar gum is frequently used in the production of rice noodles. Hydrocolloids, such as guar gum, are widely used in the production of rice noodles. The amount of addition ranges between 0.2 and 0.5% of the total weight of the flour used.

There are five stages in the development process of turning red rice into red rice noodles. The first stage in the process of making red rice noodles is mixing. The first step in making noodles is mixing. Red rice sprout flour and *Vigna radiata* sprout flour are mixed with water. The mixing produced a uniform distribution of ingredients as well as even hydration of the flour. The second stage, steaming. The steaming process takes about 40-45 minutes. The starch in brown rice partially gelatinizes during steaming. The dough was then kneaded to distribute the partially gelatinized starch. The third stage is the gelatinization of tapioca starch. Tapioca flour is used as an adhesive and improves the texture of noodles, therefore gelatinization is carried out in tapioca flour before use. The manufacturing process begins with the creation of tapioca flour that has been perfectly gelatinized. This is accomplished by combining tapioca flour with water and heating it to a clear colour (gelatinized). The process of gelatinizing tapioca flour in the production of brown rice noodles is critical to achieving the desired chewy noodle texture (Chantaro and Pongsawatmanit, 2010). The fourth stage is mixing all of the constituent materials. The perfectly sealed tapioca flour is then combined with a dough of red rice sprout flour, *Vigna radiata* sprout flour, and sago starch, which is then stirred until a homogeneous dough forms. The fifth stage is sheeting. The sheeting of dough method was used to make flat noodles in this study's development of brown rice noodles (Ahmed *et al*., 2016). Rice noodles are commonly prepared in two ways: sheeting of dough to create flat noodles and frying of dough to create fried noodles. The sixth stage is noodle steaming. Red rice noodles are steamed for 50 mins until all of the red rice noodles are fully gelatinized. The seventh stage, drying. After noodles are steamed, the noodles are dried in drier cabinets to a moisture content of about 12%. The drying red rice noodles are packaged and kept in a dry place.

This study produced up to three formulations of germinated red rice noodles. The proportion of the constituent ingredients, namely germinated red rice flour and white rice flour, differs between the three formulations. The process of making germinated red rice noodles consists of seven stages: mixing, steaming, gelatinization, mixing all ingredients, sheeting, steaming, and drying. Based on the three noodle formulations tested, it is clear that the proportion of germination red rice flour used affects the shape and texture of the noodles, as well as the content of bioactive compounds and antioxidant activity. This research resulted in the transformation of red rice noodles into functional, consumer-acceptable products. As a result, research on the development of red rice noodles is supported by chemical composition analysis, functional potential as an antioxidant, and sensory evaluation to determine the formulation of noodles that consumers will accept.

3.2 Chemical composition analysis

Table 1 shows an analysis of the chemical composition of gluten-free organic red rice noodles. According to the analysis results, the water content is between 12 and 13%. This moisture content has a significant impact on the shelf life of organic red rice noodles. This product is a staple food that can be stored for a long time. The moisture content of dry rice noodle products is typically 15% because it affects shelf life (Lu and Collado, 2019; Low *et al.,* 2020). Gluten-free organic red rice noodles have a protein content ranging from 5-8%. This protein is derived from its constituent ingredients: organic red rice and *Vigna radiata*. Gluten-free organic red rice noodles have a low-fat content, ranging from 0.1 to 0.3%. Carbohydrate levels ranged from 72 to 74%.

Compared to white rice noodles, these gluten-free organic red rice noodles, formulations I, II, and III, had a significantly higher content of resistant starch ($p<0.05$). The resistant starch content is derived from the gradual process of making rice noodles. Several stages in the production of organic red rice noodles, including starch gelatinization, steaming, and cooling, can increase the levels of resistant starch. This is consistent with research indicating that the steaming process can increase resistant starch levels (Leszczynski, 2004; Abioye *et al.,* 2017).

As a component of dietary fibre, RS3 is a prebiotic, or a medium for "probiotic," or intestinal microflora that

Table 1. Chemical composition of different types of gluten-free organic red rice noodles and white rice noodles (control)

	Control	Formulation I	Formulation II	Formulation III
Water content (%)	13.11±0.10^{c}	13.29±0.16^{d}	12.47±0.06^{a}	12.62±0.10^{b}
Ash (%)	0.45±0.08^{a}	1.513±0.11^{d}	1.22±0.07^{c}	1.17±0.10^{b}
Protein (%)	6.23±0.12^{a}	6.37±0.05^{b}	6.45±0.05^{c}	8.19±0.08^{d}
Fat (%)	0.42±0.01^{d}	0.27±0.03^{b}	0.18±0.03^{a}	0.34±0.04^{c}
Carbohydrate (%)	75.65±0.03^{d}	73.84±0.13^{c}	73.53±0.23^{b}	72.13±0.06^{a}
Resistant Starch (%)	6.07±0.04^{a}	7.56±0.02^{d}	7.31±0.04^{c}	7.17±0.02^{b}
Soluble dietary fibre (%)	0.6±0.02^{a}	0.79±0.08^{d}	0.76±0.02^{c}	0.71±0.03^{b}
Insoluble dietary fibre (%)	6.28±0.45^{a}	6.73±0.18^{b}	7.06±0.04^{c}	7.42±0.04^{d}

Values are presented as mean±SD. Values with different superscript within the same row are significantly different ($P<0.05$).

has beneficial effects on the human body. In the large intestine, resistant starch is fermented by bacteria to produce short-chain fatty acids. The slow digestion properties of RS result in the release of glucose. When compared to no dietary fibre, RS3 has physiological benefits and improves colonic health by increasing the rate of crypto cell production or decreasing colonic epithelial atrophy (Raigond *et al.,* 2015).

The results of this study show that the content of dietary fibre, both soluble and insoluble dietary fibre, is higher in gluten-free organic red rice noodles formulations I, II, and III than in white rice noodles (control) (p<0.05). The soluble and insoluble dietary fibre content increased in tandem with the increase in germinated organic red rice. Dietary fibre, both soluble and insoluble, is beneficial to health. According to this study, organic red rice noodles contain 7-8% dietary fibre. Food can be considered a fibre source if it contains at least 4% dietary fibre. Food is classified as a source, and at least 6% of the food is classified as high food (Foschia *et al.,* 2013). According to this, gluten-free organic red rice noodles used in this study could be a good source of dietary fibre. Dietary fibre is obtained from organic red rice sprout flour and *Vigna radiata*. Fibre can bind bile salts (the end product of cholesterol), which are then secreted along with feces. As a result of its ability to lower cholesterol levels in blood plasma, dietary fibre is thought to reduce and prevent the risk of cardiovascular disease (Satija and Hu, 2012). Insoluble dietary fibre can help prevent gastrointestinal diseases, colon cancer and reduce the risk of type 2 diabetes (Mudgil and Barak, 2013). While soluble dietary fibre has been linked to a lower glycemic response, it is important to keep blood glucose levels stable (Alsaffar, 2011).

3.3 Total phenolic and flavonoid content

The content of bioactive compounds in organic red rice noodles was investigated in this study. Table 2 shows that three different gluten-free organic red rice noodles contain bioactive compounds, specifically phenol and flavonoids. The higher the proportion of organic red rice sprouts used, the higher the total phenol and flavonoid content. This can be determined by the fact that formulation III of gluten-free organic red rice noodles is larger than formulations I and II (p<0.05). Organic red rice noodles contain bioactive compounds derived from germinated organic red rice flour and germinated *Vigna radiata* flour. Some studies show that the germination process can increase the content of bioactive compounds (Kim and Jang, 2004; Chaiyasut *et al.,* 2017; Dias *et al.,* 2017). The presence of this bioactive compound may influence the functional potential of gluten-free organic red rice noodles. According to some studies, products derived from organic red rice and germinated organic red rice can reduce diabetes and oxidative stress. The germination of *Vigna radiata* can also increase the levels of bioactive compounds (Xue *et al.,* 2016; Van Hung *et al.,* 2020).

3.4 Antioxidant activity of gluten-free organic red rice noodles

The proportion of germinated organic red rice flour on three different organic red rice noodles was different. The percentages of organic red rice flour in formulations I, II, and III were 55%, 65%, and 75%, respectively. According to Figure 1, the higher the proportion of germinated organic red rice flour in gluten-free organic red rice noodles, the greater the antioxidant activity. The higher the antioxidant activity of gluten-free organic red rice noodle extract, the higher its antioxidant activity. This implies that its antioxidant capacity is dose-dependent.

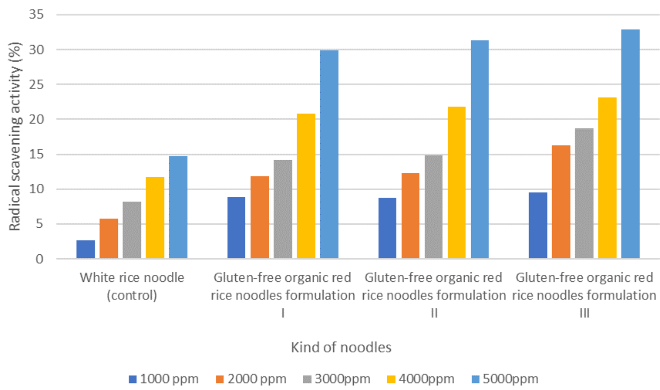

Figure 1. Antioxidant activity assayed DPPH method of three formulations gluten-free organic red rice noodles and white rice noodles (control)

Gluten-free organic red rice noodles formulation III

Table 2. Total Phenolic and flavonoid content in different types of gluten-free organic red rice noodle and white rice noodles (control)

	Total Phenolic Content (mg GAE/100 g)	Total Flavonoid Content (mg QUE/100 g)
Gluten-free organic red rice noodle Formulation I	49.16±0.27^{b}	11.23±0.69^{b}
Gluten-free organic red rice noodle Formulation II	53.36±0.86^{c}	10.55±0.32^{b}
Gluten-free organic red rice noodle Formulation III	47.96±0.40^{c}	10.28±0.73^{c}
White rice noodle (control)	3.93±0.28^{a}	4.59±0.76^{a}

Values are presented as mean±SD. Values with different superscript within the same column are significantly different (P<0.05).

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has higher antioxidant activity than formulations II and I ($p<0.05$). The presence of phenol compounds such as flavonoids and phenolic acids is primarily responsible for the antioxidant effects. Antioxidant compounds are typically phenol compounds with hydroxy groups substituted at the ortho and para positions against the clusters –OH and –OR (Liu *et al.,* 2007; Zhang *et al.,* 2018). Flavonoids are the primary constituents of plant polyphenols. According to some studies, polyphenols contribute significantly to antioxidant activity and act effectively in capturing free radicals, owing to their redox properties, which play an important role in neutralizing free radicals, singlet oxygen, triplet oxygen, or decomposing peroxides (Sahu *et al.,* 2013). Red rice had a high amount of oligomeric procyanidins (0.2 mg/g), which accounted for more than 60% of secondary metabolite content, with carotenoids and oryzanol accounting for 26.7% and flavones, flavonols, and anthocyanins accounting for 9% (Pereira-Caro *et al*., 2013). Pigmented rice like organic red rice also a source of bioactive compounds that have antioxidant activity (Huang and Lai, 2016; Thitipramote *et al.,* 2016; Samyor *et al.,* 2017)

The sample concentration required to inhibit 50% of free radicals is used to calculate the IC_{50} value. The lower the IC_{50} value, the greater the sample's antioxidant activity (Jadid *et al.,* 2017; Martinez-Morales *et al.,* 2020). Table 3 shows that the IC_{50} in organic red rice noodle formulations I, II, and III varies depending on the proportion of germinated organic red rice flour used. The IC_{50} decreases as the proportion of germinated organic red rice flour increases. Compared to formulations II and III, the IC_{50} for organic red rice formulation III is the smallest ($p<0.05$). Formulation III gluten-free organic red rice noodles have the highest antioxidant activity compared to Formulation I and II gluten-free organic red rice noodles.

Table 3. IC_{50} antioxidant activity assayed DPPH method of three types of gluten-free organic red rice noodle and white rice noodle (control)

	IC_{50}
Gluten-free organic red rice noodle Formulation I	9714.86±56.43^{b}
Gluten-free organic red rice noodle Formulation II	9665.84±72.39^{b}
Gluten-free organic red rice noodle Formulation III	9200.39±70.09^{a}
White rice noodle (control)	16872.10±157.85^{c}

Values are presented as mean±SD. Values with different superscript within the same column are significantly different ($P<0.05$).

3.5 Correlation of bioactive compounds and antioxidant activity (IC_{50})

This study discovered a significant and inverse relationship between total phenols and flavonoids and antioxidant activity as measured by DPPH (Table 4). This negative correlation indicates that the higher the total phenol and flavonoid content, the lower the IC_{50} value. The greater the antioxidant activity, the lower the IC_{50} value. This means that the higher the TPC and TFC content, the greater the antioxidant activity. According to this study, total phenols and flavonoids play an important role in antioxidant activity. In this study, antioxidant activity is closely related to phenol and flavonoid compounds in gluten-free organic red rice noodles. According to some studies, the amount of phenol and flavonoids in the body correlates with antioxidant activity (Sant'Ana *et al.,* 2014; Aryal *et al.,* 2019).

Table 4. Correlation between total phenolic and flavonoid content and IC_{50}

	TPC	TFC
IC_{50}	-0.661*	-0.550*

*Correlation is significant at the 0.05 level

3.6 Sensory characteristics

The reaction of consumers to a new product is critical in product development. A good and acceptable response is required for aroma, colour, taste, texture, and overall development as a functional food. Fifty panellists carried out sensory tests. Table 5 shows that formulation I gluten-free organic red rice noodles received the best response (colour, aroma, taste, texture, and overall reception) when compared to Formulation II and III ($p<0.05$).

The content of carotenoids such as beta-carotene and lutein in organic red rice sprout flour, a natural food colouring, influences the colour of organic red rice noodles (Bridle and Timberlake, 1997; Bustos *et al.,* 2019). The panellists' favourite texture is its elasticity and suppleness. Gluten-free organic red rice noodles have a chewy texture supported by tapioca flour and hydrocolloids (Padalino *et al.,* 2013). Organic red rice noodles typically have a bland flavour. This flavour is enhanced by the use of NaCl in the production of noodles (Lu and Collado, 2019).

4. Conclusion

The formulation I of gluten-free organic red rice noodles can be developed as functional foods based on an analysis of their chemical composition, bioactive compounds, antioxidant activity, and sensory acceptability. Gluten-free organic red rice noodles have

Table 5. Sensory evaluation of three types of gluten-free organic red rice noodles and white rice noodles (control)

	Aroma	Colour	Texture	Taste	Overall acceptance
Gluten-free organic red rice noodle Formulation I	6.44±0.58[c]	6.44±0.84[c]	6.28±0.76[c]	6.28±0.61[c]	6.66±0.63[b]
Gluten-free organic red rice noodle Formulation II	5.34±0.59[b]	5.40±0.57[b]	4.82±0.66[b]	5.16±0.68[b]	5.22±0.58[a]
Gluten-free organic red rice noodle Formulation III	3.80±0.64[a]	3.92±0.77[a]	3.98±0.74[a]	4.26±0.87[a]	5.04±0.60[a]
White rice noodle (control)	7.24±0.62[d]	7.18±0.80[d]	7.30±0.74[d]	7.38±0.85[d]	7.58±0.50[c]

Values are presented as mean±SD. Values with different superscript within the same column are significantly different ($P<0.05$).

the benefits of being high in fibre, resistant starch, low in fat, and high in bioactive compounds that support antioxidant activity.

Conflict of interest

The authors declare no conflict of interest.

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