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Formulation of Composite Flour with Antioxidant from Goroho Plantain Flour (*Musa Acuminafe, sp*) and Yellow Pumpkin Flour (*Cucurbita moschata*) and Its Application on Biscuit Making

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Abstract: Locally grown crops with phytochemical antioxidant content, i.e. goroho plantain and yellow pumpkin were used to develop composite flour. Mixture experiment with simplex lattice design was used for the formulation to study the effect of blending goroho plantain flour (GF) with yellow pumpkin flour (PF) on phytochemical content and antioxidant capacity of developed composite flours. Responses measured including phytochemical content (total phenolic and carotenoid), antioxidant capacity (DPPH assay, FRAP assay, phosphomolybdenum assay, and reducing power assay), colour values of flours, proximate components, and sensory quality of biscuits made from composite flours. The results showed that the increase in proportion of PF improved the phytochemical content, antioxidant capacity, and proximate components except for carbohydrates. However, the substitution of GF with PF reduced sensory ratings for all the sensory attributes of biscuits developed from composite flours. Among biscuits made from composite flours, sensory ratings for aroma, colour, texture, and taste were not statistically different (p>0.05). PF can be used as fortification material to improve the phytochemical antioxidant content in composite flours prepared from GF and PF, or flours from other locally grown plants.

Keywords: *goroho plantain, yellow pumpkin, antioxidant, composite flour, mixture experiment.*

INTRODUCTION

Indonesia was the world's biggest wheat importer in 2018. Most of Indonesia's imported wheat was consumed by the wheat flour industry (Workman, 2019). Wheat flour is an intermediate product and used to prepare diverse food products such as noodles, biscuits, bread, cake, and pasta. Dependency on wheat imports to meet domestic needs will absorb substantial foreign exchange, thus affect national food security. One way to reduce dependency on wheat imports is to develop composite flour-based on locally grown crops (Dendy, 1992).

Goroho plantain (*Musa acuminafe*, sp) is a local crop in North Sulawesi province of Indonesia that can be processed into flour and has the potential as a functional food due to its antioxidant and dietary fibre content (Nurali et al., 2012). Suryanto et al. (2011) reported that fresh extracts of goroho plantain flesh could scavenge DPPH radical. Goroho peel also contains antioxidant and can be used as a reducing agent to synthesize silver nanoparticles with singlet oxygen quenching activity (Suryanto et al., 2019). GF has been used as mixture to produce composite flours, some of which are with wheat flour (Sumual et al., 2009), cornflour and green bean flour (Papunas et al., 2013), cornflour and tapioca flour (Nurali et al., 2016), purple sweet potato flour (Mokodompit et al., 2017), cornflour (Suryanto and Momoat, 2017), and cornflour and sago flour (Suryanto et al., 2018).

Yellow pumpkin (*Cucurbita moschata*) is rich in carbohydrates and carotenoids that can function as an antioxidant (Kim et al., 2012). Several studies confirmed the antioxidant capacity of pumpkin, including those carried out by Gumolung et al. (2013), Idayu (2017) and Priori et al. (2017). PF has been used into different composite flours for fortification purpose, some of them with rice flour for baby biscuits making (Sundari, 2011), cornflour for cereal making (Ramadhani et al., 2012), and wheat flour for bread making (Lestario et al., 2015).

Development of functional non-wheat composite flours gained more attention in developing countries as a means to minimize the cost (Awolu et al., 2015). The utilization of composite flours for bakery products should take into account the physicochemical characteristic of the desired product, for instance, non-wheat composite flours are suitable to produce products with a minimum degree of expansion, such as biscuits (Sitanggang, 2016). Biscuits are a popular product for all ages because they offer convenience with a wide variety of choices; nevertheless, biscuits made from flour with antioxidant content that served as a functional component are still limited. The current study was aimed to investigate the mixing effect of GF with PF on phytochemical content and antioxidant capacity of developed composite flours, as well as the sensory quality of biscuits made from composite flours. Mixture experiment methodology as described by Scheffé in Murty and Das (1968) was used for formulation and to model the responses.

MATERIALS AND METHODS

1. Materials

A white variety of goroho plantain at a maturity level that meets the criteria to process into fried goroho was collected from the local market. Yellow pumpkin at a maturity level of one week before the harvest was obtained from a local farmer. All ingredients for biscuits development were bought from the local market. All chemicals for experiments were of analytical grade. The Folin-Ciocalteu reagent, ethanol, sodium carbonate, sodium hydroxide, ammonium molybdate, sodium acetate, acetic acid, hydrochloric acid, iron(III) chloride, sulfuric acid, iron(II) sulphate, potassium ferricyanide were purchased from Merck (Darmstadt, Germany). Gallic acid, 1.1-diphenyl-2-picrylhydrazyl (DPPH) were purchased from Sigma Chemical Co. (St. Lois, MO), and 2.4.6-tri-pyridyl-s-triazine (TPTZ) was purchased from Fluka, Chemic AG (Deisenhoten, Switzerland).

2. Methods

2.1 Experimental design and statistical analysis

Two factors mixture experiment with simplex lattice design was used for formulation (Table 1). The first factor was the proportion of GF (x_1) and the second factor was the proportion of PF (x_2). Responses measured included phytochemical content (total phenolic and carotenoid), antioxidant capacity (DPPH assay, FRAP assay, phosphomolybdenum assay, and reducing power assay), colour values of flour using L*a*b* colour space, proximate components, and sensory quality of biscuits made from composite flour.

Stat-Ease Design Expert 11 software package (trial version) was used to generate the regression equations and for models adequacy tests. Minitab 18 (trial version) statistical software was also used for one-way ANOVA and Tukey HDS post-hoc test with 0.05 as the α value.

Table 1. Experimental design

Coded value		Proportion as fraction of mixture (%)	
x_1	x_2	GF	PF
1.00	0.00	100	0
1.00	0.00	100	0
0.75	0.25	75	25
0.50	0.50	50	50
0.50	0.50	50	50
0.25	0.75	25	75
0.00	1.00	0	100
0.00	1.00	0	100

2.2 Preparation of goroho plantain flour (GF) and yellow pumpkin flour (PF)

Flour preparation technique as described by Suryanto et al., (2018) was followed to produce GF. Briefly, Goroho plantain was steamed for 15 min at 80°C, peeled and sliced with a thickness of 2 mm using a stainless steel knife. Prior to milling, moistures were removed by subjected the goroho slices in an electric oven set at 50°C for 9 hours. Goroho chips produced then milled to pass through an 80-mesh sieve. GF was stored in a sealed plastic bag before further analysis. The method by Prabasini et al. (2013) with minor adjustment was used to prepare PF. Shortly, yellow pumpkin was washed, cut into several pieces, and separated from the seeds. Pumpkin then steamed for 10 min at 80°C and cut into slices of 2 mm thickness. Drying with an electric oven at 50 °C for 48 hours was conducted to expel moistures from pumpkin slices. Pumpkin chips then milled to pass through an 80-mesh sieve. PF was stored in a sealed plastic bag before further treatment.

2.3 Extraction of phytochemicals

Extraction of phytochemicals from flour samples was performed using the method described by Suryanto and Momuat (2017). About 10 mL of absolute ethanol was used for flour maceration at a ratio of 1:10 (w/v). After 24 hours of maceration, samples were filtered and centrifuged at 3500 rpm for 10 min. The extracts were stored at 5°C for further analysis.

2.4 Determination of total phenolic content

Total phenolic content (TPC) was determined according to the Folin-Ciocalteu colourimetric method, as described by Suryanto et al. (2018). Extract (0.1 mL) was pipetted into a test tube, added with Folin-Ciocalteu reagent (0.1 mL, 50%) and mixed with vortex for 3 min. Then, 2 mL of 2% (w/v) Na_2CO_3 solution was added, and the mixture was kept in the dark place at room temperature for 30 min. The absorbance of the supernatant was measured at 750 nm using UV-VIS spectrophotometer. TPC was calculated as μg gallic acid equivalent (GAE)/mL using a predefined standard curve prepared with gallic acid.

2.5 Determination of total carotenoid

The method by Gross (1991) was used to determine the β-carotene content of samples. Briefly, the sample was extracted with petroleum ether and absorbance measured using a spectrophotometer at 450 nm. The concentration of carotenes expressed as β-carotene (μg/g) was calculated using the equation below:

$$\beta\text{-carotene} = \frac{A \times V \times D}{\varepsilon \times W}$$

Where A: absorbance at 450 nm, D: dilution factor, Ɛ: molar absorbance coefficient, W: the weight of sample (g), V: volume (mL).

2.6 Free radical scavenging assay

Radical DPPH (1.1-diphenyl-2-picrylhydrazyl) was used to evaluate the capacity of sample extracts to neutralize free radicals following the method described by Li et al. (2009) with slight modification. A total of 1.5 mL 0.2 mM DPPH solution in ethanol was mixed with 0.5 mL sample extract (10^5 μg/mL). After 30 min incubation in the dark at room temperature, the absorbance of mixture was read with a spectrophotometer at 517 nm using 95% ethanol as blank. Free radical scavenging capacity calculated with the equation as follow:

$$\text{Inhibition \%} = \left(1 - \frac{A}{A_o}\right) \times 100$$

Where A is the absorbance of DPPH + sample, and A_o is the absorbance of DPPH.

2.7 FRAP assay

FRAP (ferric reducing antioxidant power) assay as a means to measure the total antioxidant capacity of the sample was performed according to the method described by Szydłowska-Czerniak et al. (2008) with minor modification. The assay was performed by mixing 0.1 mL extract with

3 mL fresh FRAP reagent. The absorbance of the mixture was measured with a spectrophotometer at 596 nm. FRAP reagent was prepared by mixing 2.5 mL 2,4,6-tripiridil-s-triazine (TPTZ) solution (10 mM TPTZ solution in 40 mMHCl) with 2.5 mL of 20mM $FeCl_3 6H_2O$ and 2.5 mL of 0.3 M acetate buffer (pH 3.6). A standard curve was prepared using $FeSO_4$ solution, and total antioxidant capacity expressed as the concentration of Fe^{2+} (mmol/mL).

2.8 Phosphomolybdenum assay

Phosphomolybdenum assay was conducted according to the method explained by Prieto et al. (1999). For short, 0.3 mL extract was mixed with 0.3 molybdate reagent in a test tube. Next, the test tube was sealed with a stopper and put in water bath for 90 min set at 90°C. Absorbance was measured with a spectrophotometer at 695 nm. Molybdate reagent was prepared from 0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate. A standard curve was prepared using α-tocopherol. Total antioxidant capacity expressed as μg equivalent α-tocopherol/mL.

2.9 Reducing power assay

The method by Yen and Chen (1995) was followed to assess the reducing power of extracts. A 0.5 mL sample extract was mixed with 2.5 mL of 0.2 M phosphate buffer (pH 6.6) and 2.5 mL of 1% potassium ferricyanide. The mixture was incubated in water bath for 20 min at 50°C. Following the incubation, 2.5 mL trichloroacetic acid (10%) was added, and the mixture was centrifuged at 3000 rpm for 10 min. Next, 2.5 mL of the upper layer of the mixture was pipetted and mixed with 2.5 mL distilled water and 0.5 mL of 0.1% $FeCl_3$. An aliquot of the mixture then transferred into a cuvette and the absorbance measured by spectrophotometer at 700 nm.

2.10 Preparation of biscuit

Biscuits were developed from five combinations of GF and PF, as shown in Table 1 and prepared using the method adopted from Chandra et al. (2015). The standardized formula for biscuit comprised of 100 g flour, 25 g sugar cane, 1.25 g baking powder, 1 g salt and 52 g margarine. Margarine and sugar were mixed with dough mixer to obtain consistent cream. Other ingredients and 20 mL water were added to creamed mixture and mixed to achieve a homogeneous mixture. The dough was sheeted to a thickness of 0.5 cm, moulded, placed over a perforated oven tray and baked for 15 minutes at 180°C with a baking oven. Baked biscuits cooled at room temperature, sealed in a plastic bag and stored in room temperature until sensory testing.

2.11 Sensory evaluation

Sensory evaluation was performed according to the Indonesia standard method (SNI 01-2346: 2006). Thirty-five untrained panellists were selected from students of Faculty of Public Health to rate biscuit samples in term of colour, aroma, taste and texture using 7 point hedonic scales ranging from 1 (dislike very much) to 7 (like very much). Data collected were subjected to statistical analysis using ANOVA with post-hoc Tukey HSD test.

2.12 Determination of proximate composition and colour measurement of flours

Proximate composition was determined according to the Indonesian standard method (SNI 01-2891: 1992). Colour measurement was conducted with chroma meter (Konica Minolta CR-400) using the CIEL*a*b* colour scale.

RESULTS AND DISCUSSIONS

1. *Phytochemical content*

Total phenolic content and β-carotene were the phytochemicals antioxidant that analysed in the present study. According to Eberhardt et al. (2000), a mixture of antioxidants will provide a better effect on human health through a collaborative mechanism. Based on the results of the study PF flour extract had the greatest TPC compared to GF extract and composite flour extracts (Formula 25:75, 50:50, 25:75). Greater TPC in PF extract can be attributed to two things. First, greater bioavailability of phenolic compounds in yellow pumpkin than in goroho plantain, and second, the technique and solvent used for extraction were better to recover the phenolic compounds from PF than from GF. TPC ranged from 1.63 to 109.9 **μg GAE/mL** (Figure 1a). TPC in extracts was increased with an increasing proportion of PF. Among the composite flours increase in TPC were significant (p<0.05). Kanopa et al. (2012) and Togolo et al. (2013) also reported TPC in GF extract, respectively 7.04 mg GAE/kg extract and 20 mg GAE/kg extract.

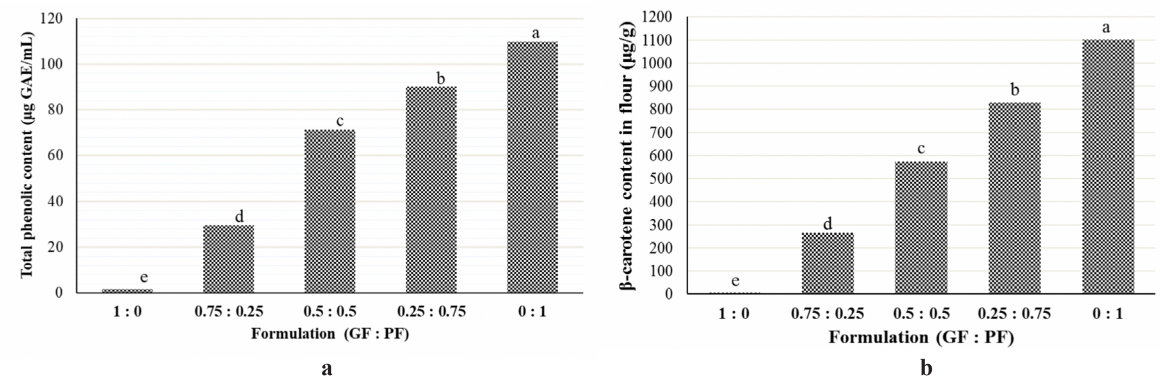

Figure 1. TPC (a) and β-carotene (b) content.

GF: goroho plantain flour, PF: yellow pumpkin flour. Each value represents a mean (n = 2). Different letters denote significant differences among means.

Figure 1b shows the content of **β-**carotene in flour increased with the increase of PF proportion. This result was in line with the shift in L*a*b*colour component value of flour when the proportion of PF increased (Table 2). The decrease of L* value and increase in b* value has a correlation with the increase in lutein, while the increase of a* value correlates with the increase in total carotenoids (Itle and Kabelka, 2009). Lutein and **β-**carotene are the most abundant carotenoids in yellow pumpkin with a percentage of 39.4% and 21.6% of total carotenoids, respectively (Gross, 1991). **Β-**carotene content of flours ranged from 6.54 to 1101.71 µg/g. **Β-carotene** content of PF is higher when compared to that reported by Trisnawati et al. (2014) (276.59 µg/g), but lower than the value reported by Prabasini et al. (2013) (4468.7 µg/g). In the determination of TPC and β-carotene content, the difference in results when compared with other studies could arise possibly due to the difference in type (cultivar or sub cultivar) of crops used as raw materials, flour preparation technique, and solvents for extracting.

2. *Antioxidant capacity*

The chemical diversity of antioxidants makes the process of separation and measurement of antioxidants in the biological/food matrix becomes difficult; therefore measuring the combined strength of antioxidants is considered more meaningful. Accordingly, researchers were more interested in measuring total antioxidant capacity directly from plant extracts (Apak, 2016). In the present study, the antioxidant potential of extracts was examined using four methods.

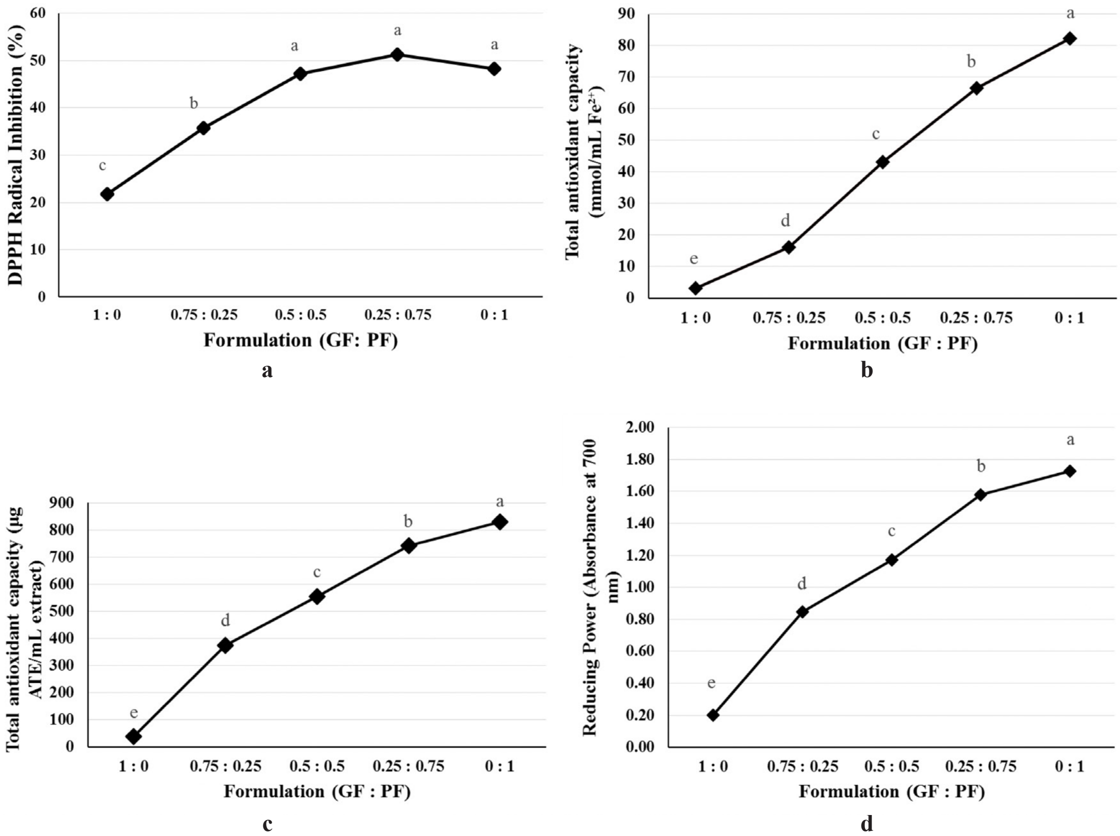

Figure 2. Antioxidant capacity: DPPH assay (a), FRAP assay (b), phosphomolybdenum assay (c), and reducing power assay (d).

GF: goroho plantain flour, PF: yellow pumpkin flour. Each value represents a mean (n = 2). Different letters denote significant differences among means.

Free radical scavenging capacity for five formulation of flours ranged from 21.79% (formula 1: 0) to 51.3% (formula 0.25: 0.75) (Figure 2a). By increased the proportion of PF to 25% (formula 0.75: 0.25) and 50% (formula 0.5: 0.5), the free radical scavenging capacity of flours increased significantly (p<0.05). Further increase in the proportion of PF to 75% (formula 0.25: 0.75) did not show a significant increase in free radical scavenging capacity (p> 0.05). Phenolic compounds extracted from flours will provide hydrogen atoms or donate electrons to DPPH molecules and converted them into stable molecules which produce a decrease in absorbance at 517 nm (Molyneux, 2003).

In assaying total antioxidant capacity with FRAP method, Fe^{2+} ions were produced as reducing the product of Fe^{3+} by the presence of antioxidants. The amount of Fe^{2+}-TPTZ complexes formed at pH of 3.6, which correlates with antioxidant concentration, measured by spectrophotometer at 596 nm. In acidic solution (around a pH of 3.6), phenolic antioxidants are not dissociated so that the measured antioxidant capacity with FRAP method is lower than the actual one. This is due to phenolic ions (dissociation product of phenol) are oxidized faster (faster in donating electrons) compared to phenol. Furthermore, the FRAP method cannot measure the antioxidant capacity of carotenoids (Apak et al., 2016; Apak et al., 2013), suggesting that only the phenolic compounds contribute to the total antioxidant capacity. Total antioxidant capacity of flour extracts ranged from 3.12 to 82.38 mol Fe^{2+}/L extract (Figure 2b), raised as the proportion of PF increased.

Phosphomolybdenum assay measures the reducing capacity of antioxidants against Mo(VI). The concentration of Mo(V), which demonstrates the total antioxidant capacity of extracts ranged from 37.72 to 830 µg ATE/mL extract. Similar to FRAP assay results, an increase in total antioxidant capacity also observed as the proportion of PF increased. The finding was consistent with the phytochemical analysis that revealed an increase in phytochemical content when the proportion of PF increased.

Reducing power of extracts reflects their antioxidant capacity. The reducing power was measured by the amount of Fe^{2+} formed according to the following equation: $K_3[Fe(CN)_6] \rightarrow K_4[Fe(CN)_6]$. The Development of turquoise colour in solution which marked the presence of Fe^{2+} as reducing product was analyzed with a spectrophotometer. Increase in absorbance at 700 nm indicates an increase in reducing power (Siddhuraju et al., 2002).

All extracts exhibited reducing power that ranged from 0.20 to 1.73. Extract from a different formula of flour had different reducing power ($p<0.05$). Increase in reducing power was in the following order: Formula 1:0 (GF) < Formula 75:25 < Formula 50:50 < Formula 25:75 < Formula 0:1 (PF). This finding was in line with their antioxidant capacity measured with FRAP method and Phosphomolybdenum assay, which showed an increase in antioxidant capacity with an increased proportion of PF. Reducing power of extract demonstrate its ability to counter free radicals by the electron transfer mechanism.

3. *Proximate composition and colour value*

Colour analysis revealed that L*a*b* values of five flour formulas were statistically different ($p<0.05$). Increased PF proportion led to a decrease in L* value, and conversely, increase in b* value and a* value. Visually, the colour of flours became darker and yellower as the proportion of PF increased. Vibrant yellow/orange colour of pumpkin derived from its high carotenoids content, especially beta carotene and lutein. Colour shifting of composite flours as the proportion of PF increased characterized an increase in carotenoids content. Colour analysis of PF shows considerably close values to that reported by Pongjanta et al. (2006).

Table 2 presents the proximate composition of flours. Moisture, ash, crude protein, crude fibre, and fat content in composite flours increased with the increase in the proportion of PF. Conversely, carbohydrate content in composite flours decreased with the increase of PF proportion. Proximate component of GF (formula 1: 0) in this study has a relatively close value to that reported by Nurali et al. (2012). Meanwhile, a proximate component of PF (formula 0: 1) shows very close values to that reported by Kristiyani (2016).

Table 2. Physicochemical properties of flours

Physicochemical properties	Formulation (GF : PF)				
	1 : 0	0.75 : 0.25	0.5 : 0.5	0.25 : 0.75	0 : 1
Colour (L^*)	79.80 ± 0.12^a	72.64 ± 0.05^b	67.44 ± 0.06^c	$65.05 \pm 0{,}30^d$	62.34 ± 0.29^e
(a^*)	3.82 ± 0.07^d	4.01 ± 0.13^d	5.46 ± 0.04^c	6.13 ± 0.04^b	7.82 ± 0.00^a
(b^*)	13.29 ± 0.06^d	30.48 ± 0.23^c	34.92 ± 0.00^b	37.20 ± 0.08^a	37.52 ± 0.25^a
Moisture (%)	6.11 ± 0.22^c	7.75 ± 0.45^b	8.04 ± 0.10^b	9.07 ± 0.06^a	9.52 ± 0.23^a
Ash (%)	2.22 ± 0.22^c	2.88 ± 0.22^{bc}	3.12 ± 0.34^b	5.64 ± 0.44^a	5.75 ± 0.18^a
Crude Protein (%)	2.81 ± 0.62^c	5.02 ± 0.57^{bc}	5.31 ± 0.44^{bc}	7.78 ± 1.10^{ab}	10.15 ± 0.66^a
Fat (%)	$0.35 \pm 0{,}03^c$	1.82 ± 0.16^{bc}	3.21 ± 0.04^{ab}	4.67 ± 0.14^a	4.85 ± 0.97^a
Carbohydrate (%)	88.53 ± 1.02^a	82.38 ± 0.21^b	80.16 ± 0.72^b	72.98 ± 0.43^c	69.54 ± 0.65^d
Crude fibre (%)	1.65 ± 0.34^b	3.52 ± 0.95^{ab}	5.14 ± 0.52^a	5.88 ± 0.83^a	5.42 ± 0.62^a

Values expressed as mean ± SD (n = 2). GF: goroho plantain flour, PF: yellow pumpkin flour. Different superscripts within the same row denote significant differences among means.

4. *Sensory Evaluation*

Sensory evaluation mean scores are presented in Figure 3. In general, the sensory rating of biscuits developed from composite flours was lower compared to biscuits made from 100% GF in terms of aroma, colour, texture, and taste. Sensory ratings of biscuits made from composite flours ranged from “dislike slightly” to “neither like nor dislike”. Among biscuits made from composite flours, sensory ratings for aroma, colour, texture, and taste were not statistically different ($p>0.05$). Only biscuits made with formula 0.75:0.25 had a sensory rating for colour that was not significantly different ($p>0.05$) with biscuits made from 100% GF. Biscuits with brighter colour were more preferred by the panellists (Student; age 20-22; 75% female and 25% male) selected in this study. Lower sensory rating in terms of taste and texture for biscuits made from composite flours is probably a consequence of including the pumpkin peel in PF preparation. Biscuits made from 100% GF were sweater and softer compared to biscuits made from composite flours.

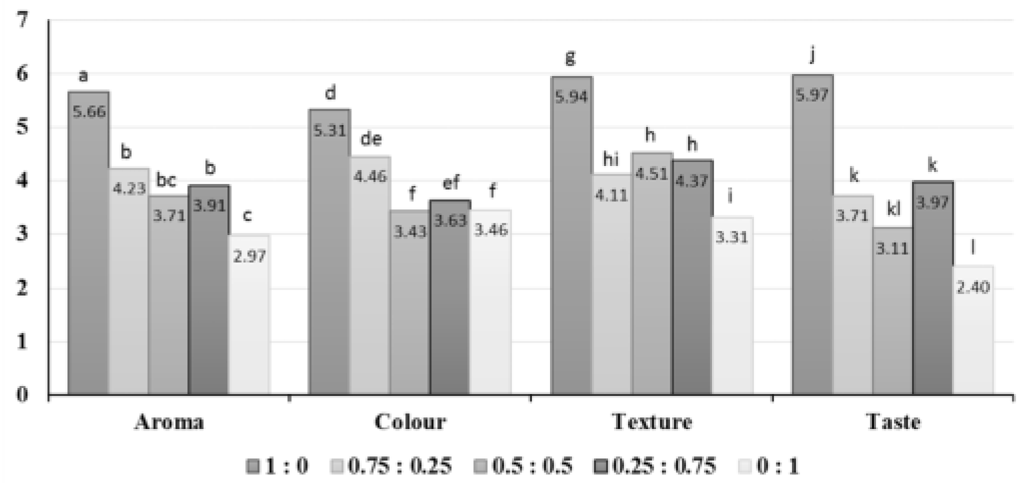

Figure 3. Sensory attributes of biscuits made from five formulas (GF:PF). GF: goroho plantain flour, PF: yellow pumpkin flour. Each value represents a mean (n = 35). Different letters denote significant differences among means.

5. *Regression analysis*

Regression models for total phenolic content, beta carotene content, free radical scavenging capacity, and total antioxidant capacity (FRAP and phosphomolybdenum methods) were significant (p<0.05), had insignificant lack of fit (p>0.05) and had a coefficient of determination above 90%. Coefficients of linear element on all models had positive values, with coefficients for x_2>x_1. Based on the models presented in Table 3, PF was the main contributor to the increase in phytochemical content and antioxidant capacity of composite flours. The regression model in Table 3 also can be used in the food processing industry as a predicting tool to obtain optimum response based on optimum cost.

Table 3. Regression equations

Response	Model	p (model)	*Adjusted R^2*	p (*Lack of fit*)
TPC	$0.38x_1 + 111.15x_2 + 61.83x_1x_2 - 161.35x_1x_2(x_1 - x_2)^2$	< 0.0001	0.9939	0.0782
β-carotene content	$4.65x_1 + 1105.84x_2$	< 0.0001	0.9969	0.3701
Free radical inhibition	$21.27x_1 + 48.68x_2 + 47.11x_1x_2$	< 0.0001	0.9702	0.4326
Total antioxidant capacity (FRAP assay)	$2.67x_1 + 81.93x_2 - 57.61x_1x_2(x_1 - x_2)$	< 0.0001	0.9962	0.5122
Total antioxidant capacity (Phosphomolymdenum assay)	$43.68x_1 + 824.96x_2 + 485.19x_1x_2 + 708.81x_1x_2(x_1 - x_2)^2$	< 0.0001	0.9953	0.1064

x_1: Proportion of GF in coded value, x_2: Proportion of PF in coded value. GF: goroho plantain flour, PF: yellow pumpkin flour

Utilizing local non-wheat crops as ingredients in food products has a positive impact on the economy. In addition, functional components in local crops also possess potential health benefits. Gluten-free biscuits are a possible choice for those with celiac disease. Antioxidants in diets exert a potential protective effect against oxidative damages caused by reactive oxygen species in the human body. Reduction risk of many chronic diseases has been associated with the consumption of high antioxidant diets from plants (Mehta and Gowder, 2015). The current study showed that composite flour developed from GF and PF could be used as an alternative flour with antioxidant to produce a minimum degree of expansion product such as biscuit.

CONCLUSION

The results revealed that mixing GF and PF increased the phytochemical content, the total antioxidant capacity of composite flours and proximate components content with the exception of carbohydrates. Sensory rating of biscuits developed from composite flours was lower compared to biscuits made from 100% GF in terms of aroma, colour, texture, and taste. Among biscuits made from composite flours, sensory ratings for aroma, colour, texture, and taste were not statistically different. PF can be used as fortification material to improve the phytochemical antioxidant content in composite flours prepared from GF and PF, or flours from other locally grown plants.

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