J. Trop. Agric. and Fd. Sc. 53 (2)(2025): 11 – 15

Sensory acceptance and nutritional potential of high fibre rice-based cookies fortified with pickled guava core powder

Lee, A.[1*], Khalid, K. H.[2] and Shamsuddin, N.[1]

[1]*Technology Transfer and Entrepreneurs Development Centre, MARDI Pulau Pinang, 13200 Kepala Batas, Pulau Pinang, Malaysia*
[2]*Food Science and Technology Research Centre, MARDI Headquarters, 43400 Serdang, Selangor, Malaysia*

Abstract

Study on the potential of Pickled Guava Core Powder (PGC-powder) for producing high fiber rice-based cookies (HFC) has been conducted. The PGC-powder was incorporated into rice-based cookies (RC) as additional ingredient to enhance the nutritional quality. Nutritional content and sensory acceptance were compared between RC and HFC. The nutritional analysis on HFC showed that it contains 518 kcal energy, 60.5 % carbohydrate, 26.9 % fat, 8.5 % protein, 8.3 % of insoluble fibre and 2.2 % ash. There was no significant difference (p >0.05) for nutritional content between HFC and RC except for energy and insoluble fibre content. Furthermore, HFC exhibited lower water activity (a_w = 0.26) and moisture content (1.60 %) compared to RC. In terms of color, both cookies had similar lightness (L-values), although HFC demonstrated lower a- and b-values, indicating reduced redness and yellowness. Sensory evaluation involving 112 panelists revealed no significant differences (p >0.05) in odour, colour, taste, texture and overall acceptability between HFC and RC. This study has proven that PGC-powder successfully improves the nutritional profile of rice-based cookies without compromising consumer acceptance.

Keywords: *guava, industrial by-product, high fibre, rice-based cookies*

Introduction

Cookies are widely consumed sweet baked products typically made from ingredients such as flour, eggs, sugar, leavening agents, milk, flavours and others. Various cookies found in the market are made of wheat flour which known to be unsuitable for gluten intolerant consumers. Coeliac disease patient is strictly prohibited from taking any food products containing gluten such as baked goods, cereals and processed food with gluten derivatives (Gallagher et al. 2004). Due to this concern, rice flour is the most suitable substitute to wheat flour as it is gluten-free, low sodium content, contains fibre, fat, and more digestible carbohydrates (Sivaramakrishnan et al. 2004). Starch and protein in rice flour are the important compounds that contributes to its physicochemical properties (Asmeda et al. 2016). Although rice flour lacks the gluten proteins that confer structure and elasticity in most baked products, it is not a limitation in cookie production as this product does not require a high degree of structural extensibility for fluffy texture. Therefore, rice flour is the most suitable gluten-free flour for making cookies.

High fibre rice-based cookies has been developed by MARDI since 2012. Brown rice flour from MR 219 rice variety was used as wheat flour substitute for MARDI's high fibre rice-based cookies (Rosniyana et al. 2013). Despite their nutritional advantages, such products have not been widely commercialised due to limited market availability of brown rice flour causing disinterest in entrepreneurs. As a solution, fermented guava waste was developed into powder and incorporated into cookies made from milled white rice to boost its fibre content. Previous study by Lee (2021) stated that Pickled Guava Core Powder (PGC-powder) contains 63.6 % dietary fibre which can be regarded as potential food ingredient for producing high fibre cookies. According to Ajay (2015), dietry fibre may increase the functional properties in food products such as water or oil holding capacity, gel formation and swelling capacity. Dietry fibre is known for

Article history
Received: 04.06.2025
Accepted: 05.10.2025

Author's full names: Aslinah Lee Nyuk Fong Md Rizal Lee, Khairunizah Hazila Khalid and Norlee Shamsuddin
Corresponding author: linahlee@mardi.gov.my

promoting healthy digestive system and preventing heart disease (Ajay et al. 2015). This study was undertaken to evaluate the nutritional quality and sensory acceptability of high-fibre rice-based cookies enriched with PGC-powder. The findings aim to demonstrate the potential of PGC-powder as a functional food ingredient while addressing food sustainability and gluten-free product development.

Materials and method

Guava core powder preparation

Pickled guava cores (PGC) were obtained from local fruit pickles manufacturer in Penang. The cores were grated and soaked in water at 4:1 water-to-PGC ratio for 2 – 3 hours to reduce salinity. The desalting process took for about 2 – 3 hours. PGC was drained, rinsed, and spread thinly on a tray before drying in cabinet air drier at 60^0C for 8 – 12 hours. The dried PGC was grinded into powder (PGC-powder) and sieved using commercial sifter of 40 mesh size. The resulting PGC powder was packed in polypropylene plastic bag and stored in chilled temperature (approximately 3 – 5^0 C) until further usage.

Cookies preparation

Cookie was made using rice flour purchased from local supermarket. The ingredients used in the formulation were rice flour (86.27 %), corn flour (13.73 %), sugar (96.56 %), butter (96.14 %), evaporated milk (38.63 %), baking powder (0.86 %), cocoa powder (19.30 %), eggs (19.30 %), almond powder (19.30 %) and nibbed almond (39.06 %). Butter and sugar were beaten until fluffy using cake mixer at high speed. Eggs and evaporated milk were added followed by dry ingredients and nibbed almond. The mixture was beaten at low speed until homogenous. Cookies were shaped and baked at 180 ^{0}C for 13 minutes. Two types of cookie samples were produced under this method and labeled as RC (rice-based chocolate cookie) and HFC (high fibre rice-based chocolate cookie). The HFC was added with 25.75 % PGC-powder as fiber source. Samples were packed in polypropylene plastic jar and stored at cool dry place until further analysis.

Nutritional analysis

The nutritional composition of RC and HFC was analysed for energy, fat, carbohydrate, protein, ash, moisture, starch, soluble and insoluble fibre according to the AOAC 17^{th} Edition standard methods. Water activity was measured with Aqualab Series 3TE (Decagon, USA). Color was measured with a CR-300 chroma meter (Minolta, Japan). Fatty acid profile for HFC samples was analyzed according to the AOAC 17^{th} Edition method 996.06 and results were compared to PGC-powder. All analyses were carried out in duplicates. Results were analysed using the Analysis of Variance (ANOVA) statistical method and differences between means were determined using Duncan's multiple range test.

Sensory evaluation and statistical analysis

Sensory evaluation for RC and HFC was carried out with 112 untrained panelists using 7-point hedonic scale. Sample was evaluated respectively for odour, colour, taste, texture and overall acceptability attributes. Statistical analysis was performed using Analysis of Variance (ANOVA) and mean differences were evaluated using Tukey's test at a significance level of $P = 0.05$, with Minitab software (version 16)

Results and discussion

Nutritional compositions

The nutritional profiles of RC and HFC are presented in *Table 1*. Results showed no significant differences ($p > 0.05$) of fat, protein, carbohydrate, ash and moisture content for between the two samples. However, the ash content for HFC was found to be higher than RC. Study by Lee (2021) and Silva & Morais (2014) found that guava core is high in mineral content such as potassium, magnesium and iron which indirectly explained the higher ash content in HFC than RC. There was significant difference ($p < 0.05$) for energy, insoluble fiber and water activity between the two products. Water activity in HFC was lower than RC could be due to the free-water was bound by dietary fibre in HFC. Dietary fibre possesses unique functional properties such as water and oil holding capacity, swelling capacity and gelling formation which can impart desired texture quality in certain food (Ajay et al. 2015). Water entrapped by any macromolecules in food matrices is not readily flow and easily removed when subjected to heat (David & Owen, 2008). Energy was determined through calculation by factors 4 kcal/g for carbohydrate and protein, and 9 kcal/g for fat. The amount of fat was higher in RC than HFC (*Table 1*), thus energy content for RC was higher ($p < 0.05$). The dietary fiber in PGC-powder has significantly ($p < 0.05$) increased the insoluble fibre content of HFC compared to RC. Several studies have reported that guava powder contains more than 40 % of dietary fibre (Jiménez-Escrig et al. 2001; Ajay et al. 2015; Lee et al. 2021) and Ajay et al. (2015) highlighted that guava peel and pulp can become source of antioxidant.

Table 1: Nutritional comparison of high-fibre rice-based cookies (HFC) and rice-based cookies (RC)

Parameter	Results (mean±SD)	
	HFC	RC
Energy, kcal	518 ± 1.41[b]	528 ± 1.41[a]
Fat, g	26.9 ± 0.42[a]	28.1 ± 0.42[a]
Carbohydrate, g	60.5 ± 0.85[a]	60.3 ± 0.99[a]
Protein, g	8.5 ± 0.42[a]	8.5 ± 0.42[a]
Ash, %w/w	2.2 ± 0.14[a]	1.8 ± 0.14[a]
Insoluble fibre, %w/w	8.3 ± 0.28[a]	5.3 ± 0.28[b]
Soluble fibre, %w/w	0	0
Starch, %	18.6	20.5
Water activity, Aw	0.26 ± 0.01[b]	0.31 ± 0.00[a]
Moisture, %w/w	1.60 ± 0.06[a]	1.75 ± 0.13[a]

Means within row with the same letter are not significantly different at p >0.05.
HFC = High fibre rice-based cookies, rc = Rice-based cookies

Fatty acid profile

Fatty acids comparison for PGC-powder and HFC are shown in *Table 2*. PGC-powder contained unsaturated fatty acids such as linoleic acid (5.0 %), trace amount of oleic acid (0.7 %) and linolenic acid (0.1 %). These essential fatty acids are found less in HFC cookies which only incorporated 25 % of PGC-powder. However, there was an increase of linolenic acid (0.6 %) observed in HFC likely due to the presence of almond powder which is known to contain multiple unsaturated fatty acids, including linolenic acid which incorporated as one of the ingredients in HFC formulation. According to Ivo oliveira et al. (2020), linolenic acid is among the 13 fatty acids found in almond and reported that α-linolenic acid increased tremendously when almond is treated with heat particularly blanching and roasting. The amount of fat used in HFC cookies has increased the saturated fatty acids compound particularly lauric and myristic acid.

Table 2. Comparison of fatty acids profile between pickled guava core powder (PGC-powder) and high-fibre rice-based cookies (HFC)

Fatty acid	Results (mean %)	
	PGC powder	HFC
Linoleic acid (n-6)	5.0	0.1
Oleic acid (n-9)	0.7	0.0
Palmitic acid (C16:0)	0.6	0.0
Stearic acid (C18:0)	0.4	0.0
Linolenic acid (C18:3)	0.1	0.6
Lauric acid (C12:0)	0.0	7.8
Myristic acid (C14:0)	0.0	9.7
Palmitoleic acid (C16:1)	0.0	1.2

PGC = Pickled guava core, HFC = High fiber rice-based cookies

Cookies colour comparison

Color difference can be defined as the numerical comparison of a sample's color to the standard. It indicates the differences in absolute color coordinates and is referred to as L-value, a-value, and b-value. L-value indicates the difference in lightness and darkness (+ = lighter, - = darker). The a-value tells us the difference in red and green (+ = redder, - = greener). The b-value shows us the difference in yellow and blue (+ = yellower, - = bluer). Color differences between RC and HFC are summarised in *Table 3*. Result from *Table 3* showed no significant difference (p >0.05) in lightness for HFC and RC. However, RC had significantly (p <0.05) higher a-value (redness) and b-value (yellowness) compared to HFC, with 0.48 points more red and 0.44 points more yellow, respectively. Both cookies exhibited yellow tone, where RC is significantly (p <0.05) yellower than HFC. The darker visual appearance of both samples may be attributed to Maillard reactions that occur during baking. According to Mouminah (2025), the Maillard Reaction which closely related to the levels of reducing sugar, amino acids and protein might have contributed to the darker tone of cookies during baking process.

Table 3. Comparison of cookies color between HFC and RC

Product	Result (mean±SD)		
	L	a	b
HFC	29.74 ± 0.21[a]	5.17 ± 0.06[b]	8.36 ± 0.21[b]
RC	29.57 ± 0.47[a]	5.65 ± 0.12[a]	8.80 ± 0.05[a]

Means within column with the same letter are not significantly different at p >0.05.
HFC = High fiber rice-based cookies, RC = Rice-based cookies

Sensory evaluation

Results from the sensory evaluation are presented in *Table 4*. No significant differences (p >0.05) were observed between RC and HFC for all five sensory attributes; colour, odour, taste, texture and overall acceptability. Though the differences between both samples were undetected, the acceptance for colour and taste showed dissimilar degree of preference scale. Panelists slightly preferred the color of HFC than RC while for taste, panelists chose RC over HFC. HFC has lighter color than RC which resulted slightly higher preference by panelists (*Image 1*). Despite minor differences in preference, both cookie variants received comparable scores for texture and overall acceptability (*Table 4*). This suggests that the incorporation of PGC-powder into rice-based cookies does not negatively impact sensory properties, supporting its potential use in functional food applications.

Image 1: From left to right: HFC appeared lighter in colour compared to RC.

Table 4. Sensory preference test for HFC and RC

Product	Colour	Odour	Taste	Texture	Overall acceptability
HFC	6.08 ± 0.74[a]	5.78 ± 0.94[a]	5.95 ± 0.94[a]	5.97 ± 0.95[a]	6.07 ± 0.73[a]
RC	5.95 ± 0.97[a]	5.88 ± 0.87[a]	6.17 ± 0.88[a]	5.97 ± 0.88[a]	6.17 ± 0.80[a]

Means within column with the same letter are not significantly different at $p > 0.05$. N=112
HFC = High fibre rice-based cookies, RC = Rice-based cookies

Conclusion

The incorporation of Pickled Guava Core Powder (PGC-powder) into rice-based cookies significantly enhanced the nutritional quality of the product, particularly by increasing its insoluble dietary fibre content. Compared to the control sample (RC), the high-fibre cookie (HFC) demonstrated lower energy, fat and moisture contents, as well as reduced water activity; these features contribute to improved shelf stability and health benefits. Importantly, HFC was found to be acceptable to consumers, showing no significant differences in sensory attributes compared to RC. This study has succeeded in producing high fibre cookies using potential dietary fibre from pickled fruit by-product. Besides, it also proven that by-product from pickled fruit industries can be benefited as profitable food ingredient.

Acknowledgement

Thanks to Technology Transfer and Entrepreneur Development Centre (MARDI) for funding this project. Million thanks to Food Science and Technology Research Centre (MARDI) for facilities and personnel involved. May this article bring valuable information to Malaysian food industry players.

References

Ajay, K. M., Rajendra, K. P., Dipti, R., Paras, P. & Dinesh, C. R. (2015). Waste product of fruits and vegetables processing as a source of dietary fibre: a review. *Trends in Biosciences*, *8*(19), 5129–5140.

AOAC. (2000). Official Methods of Analysis, 17th ed. Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Asmeda, R., Noorlaila, A. & Norziah, M. H. (2016). Relationships of damaged starch granules and particle size distribution with pasting and thermal profiles of milled MR263 rice flour. *Food Chemistry*, *191*, 45–51.

Ivo oliveira, Goufo, P., Trindade, H. & Gonçalves, B. (2020). *plants Effects of Different Processing Treatments on Almond*. 1–18.

David S. Reid & Owen R. Fennema. (2008). water and ice. In *Fennema's Food Chemistry* (pp. 31–33).

Gallagher, E., Gormley, T. R. & Arendt, E. K. (2004). Recent advances in the formulation of gluten-free cereal-based products. *Trends in Food Science and Technology*, *15*(3–4), 143–152.

Jiménez-Escrig, A., Rincón, M., Pulido, R. & Saura-Calixto, F. (2001). Guava fruit (Psidium guajava L.) as a new source of antioxidant dietary fiber. *Journal of Agricultural and Food Chemistry*, *49*(11), 5489–5493.

Lee, A., Khalid, K. H. & Shamsuddin, N. (2021). Pickled guava core powder : An application of reprocessed industrial waste for producing high-fibre condiment powder. *Journal of Tropical Agriculture and Food Science*, *49*(1), 1–6.

Lee Nyuk Fong M. R. L., A., Hazila, K. & Shamsuddin, N. (2021). Pickled guava core powder: An application of reprocessed industrial waste for producing high-fibre condiment powder. In *J. Trop. Agric. and Fd. Sc* (Vol. 49, Issue 1).

Rosniyana A., Aslinah L., Mohd Ariff W., Mohamad Zin Ahmad, N. S. (2013). Teknologi pembangunan cookies beras perang dan kraker beras.

Silva, J. & Morais, S. M. de. (2014). *Chemical composition , fatty acid profile and bioactive compounds of guava seeds (Psidium guajava L .). July*.

Sivaramakrishnan, H. P., Senge, B. & Chattopadhyay, P. K. (2004). Rheological properties of rice dough for making rice bread. *Journal of Food Engineering*, *62*(1), 37–45.

Mouminah H. H. & Althaiban M. A. Production and Evaluation of Gluten-Free Cookies for Celiac Patients Made from Rice Flour and Green Banana Flour (2025). *Nutr Food Sci* 2025; 13(2).