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Pickled guava core powder: An application of reprocessed industrial waste for producing high-fibre condiment powder

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Abstract
A study focusing on the potential of reprocessed industrial waste for an application in food product was conducted. A collaborative research with local fruit pickles producers in Penang was done to discover the potential of pickled guava waste (the core). Pickle guava cores (PGC) were procured and processed into dried powder (PGC-powder) using air drying method. Nutritional analysis on the PGC-powder showed that it contained 55% of insoluble fibre, 8.6% soluble fibre, 9.1% protein and 6.3% fat. The PGC-powder was used to develop high-fibre guava condiment powder (GCP) as an alternative product to the commercially available condiment powder normally used to garnish cut fruits. The nutritional analysis indicated that GCP contained 15 times more insoluble fibre and two times more soluble fibre than the commercial condiment powder. Sensory evaluations were conducted (N = 110) for attributes including odor, color, taste, texture and overall acceptability. The ANOVA analysis indicated significant difference (p <0.05) in all attributes for GCP and commercial condiment powder, and an overall acceptability, showing that GCP was neither liked or disliked by the panelists. This study has proven that PGC-powder can be used in food products to enhance the nutritional value to benefit human's health.

Key words: guava, fermentation, industrial waste, powder, high fibre

Introduction

Guava or *Psidium guajava* is known as a tropical fruit cultivated mostly in Asian countries of which India, China and Thailand are the biggest producers (Worldatlas 2018). Guava has been recognized as 'super food' for containing health-promoting bioactive compounds, such as antioxidant, fibre and vitamins (Chang et al. 2014; Perez-Rocha et al., 2015). The presence of natural antioxidant compounds, such as phenolic in guava may help lower cardiovascular diseases or cancer, and prevent lipid oxidation in food products (Verma et al. 2013). Meanwhile, the significant amount of dietary fibre available in guava may also contribute to the health benefit while improving the overall texture of certain food products, particularly involving water and fat-binding capacity (Verma et al. 2013). The recent study on guava powder has been associated with its potential in enhancing physiological, functional and nutritional attributes of meat products (Verma et al. 2013).

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The general processing of pickled guava (Mohamed et al. 1993) starts with a brining process, where the entire unpeeled fruits are soaked in a 10% or 12% salt water for at least two weeks. Later, the guavas are cut into medium-sized cubes before undergoing the desalting process for several hours. The purpose of the desalting process is to remove the excessive salt from the cut pickled guavas before they are packed into plastic containers filled with syrup. During the cutting process, the middle part of pickled guava which contains the pulp and seed is usually discarded.

Most food processing industries produce a huge amount of waste after each production. Most often, the waste is discarded at the end of production day. Due to the improper disposal procedure, tons of process residues are discarded in the landfill, causing environmental pollution and raising major concerns not only to the public or authorities, but also to the industries (Sadh et al. 2018). This issue has brought the attention to one of the biggest pickled fruit producers in Penang located at northern Seberang Perai. One of their major fruit wastes comes from pickled guava, with 40 – 50% (pulp and seed) of the fruits being discarded. Not only its waste has caused unpleasant odour, but also managing tons of industrial wastes can be costly.

Due to this, the way of eliminating the negative impacts is by reprocessing the waste into material that can benefit both the environment and industry. Therefore, this study was carried out to identify the benefits and potential use of pickled guava core waste as a healthy food product or ingredient. Furthermore, pickled guava core (containing the seed) might have worthy functional nutritional quality to be discovered.

Commercial condiment powder also known as *serbuk asam boi* among the Malaysians, is a salty dried plum powder. It has a strong, distinctive flavour, with a combination of sweet, sour, tart, and salty taste. The flavourful powder is sprinkled on fresh fruits and it can be included in salads (Thompson, 2019).

Materials and methods

Powder preparation

Pickled guava cores (PGC) were obtained from Pak Ali Food Industries Sdn. Bhd. in Tasek, Simpang Ampat, Pulau Pinang. They were grated and soaked in water (ratio PGC to water was 1:4) to undergo desalting process for about 2 – 3 hours. The PGC were tossed, rinsed and spread thinly on a tray before drying in the cabinet air drier at 60 °C for 12 hours. Dried PGC was ground into powder (PGC-powder) using an industrial hammer mill and sieved using a fabricated industrial sifter of 40 mesh size (by local fabricator). The powder was packed in 6 × 9-inch polypropylene plastic bag and stored in chilled temperature (approximately 3 – 5 °C) for further use.

Guava condiment powder preparation

The PGC-powder was used as the main ingredient for processing condiment powder (used for garnishing cut fruits). The guava condiment powder was prepared by mixing PGC-powder and lime powder (80% PGC-powder + 20% lime powder) and then, it was mixed well with sugar, citric acid, salt and anticaking agent. The product was labeled as GCP (Guava Condiment Powder). The commercial condiment powder was imported from China and repacked by Pak Ali Food Industries Sdn. Bhd. The procured commercial condiment powder which consisted of sour plum powder was labeled as control. The samples were vacuum packed and stored at cool and dry place until further analysis.

Nutritional analysis

The PGC core, PGC-powder, GCP and control were analyzed in duplicate for fat (AOAC 920.39), protein (AOAC 2001.11), ash (AOAC 942.05), moisture (AOAC 934.01), and dietary fibre (AOAC 2011.25: insoluble and soluble fractions). The energy and carbohydrate were determined by

calculations (AOAC 2006). The minerals (AOAC 968.08), ascorbic acid (967.21) and fatty acid profile for the PGC-powder were also analyzed. The nutritional results of the products samples were analyzed using the one-way analysis of variance (ANOVA) under the Duncan's Multiple Range Test.

The sensory evaluations for GCP and control were conducted with 110 untrained consumer panelists using 7-point Hedonic Scale. The sample was evaluated for odor, color, taste, texture and overall acceptability attributes. The data were analyzed using the one-way ANOVA. Significant difference was determined by Tukey's Test at P = 0.05 using Minitab, version 16.

Results and discussion

Nutritional compositions

Pickled guava core (PGC)

The nutritional composition between pickled guava core (PGC) and its powder (PGC-powder) is compared in *Table 1*. The PGC-powder contained higher fat, carbohydrate, protein and dietary fibre than its core, with 6.30, 78.20, 9.10 g/100 g and 63.60% w/w, respectively. As for the mineral content, the analyses results showed higher content of magnesium and potassium in PGC-powder, which were 59.00 and 79.00 mg/100 g, respectively. The results obtained for the nutritional analyses were significantly different (p <0.05) between PGC and its powder. The PGC-powder was a dried form of PGC. There was 72% difference in water content (*Table 1*), explaining the greater difference between both for all nutrient content. However, ascorbic acid (5.90 mg/100 g) was found significantly higher (p <0.05) in PGC than its powder. Ascorbic acid is a water-soluble vitamin that can easily deteriorate when exposed to heat and soaking (Vaclavik et al. 2008). Hence, the desalting and drying process applied for making PGC-powder might greatly deteriorate this particular vitamin.

Energy was determined via calculation with factors of 4, 4, and 9 for protein, carbohydrate, and fat, respectively. The amount of protein, carbohydrate, and fat was higher in PGC-powder compared to PGC (*Table 1*). Therefore, the calculated energy of PGC-powder was higher than PGC. Furthermore, the PGC-powder is a dried form of PGC, with most of its water removed.

Guava is regarded as a high-fibre fruit, especially insoluble fibre. The PGC-powder contained 63.60% of dietary fibre, consisting of 55.0% insoluble fibre and 8.60% soluble fibre fractions. It was higher than the findings reported by Verma et al. (2013) in which the total dietary fibre of the dried guava powder was 43.21%. Furthermore, this result was strongly supported by Jimenez-Escrig et al. (2001) whom stated that guava peel and pulp were high in dietary fibre, indigestible fraction and phenolic compounds. Nicanor et al. (2001) and Chang et al. (2014) had studied guava seeds in a dried form. They found that guava seeds had 53.6 – 67.7 % raw fibre. Therefore, the PGC-powder can be considered as a potential food ingredient for developing high dietary fibre food products which can benefit the digestive system.

Table 1. Nutrients comparison between PGC and PGC-powder

Parameter	Results (mean ± SD)	
	PGC	PGC powder
Energy, kcal	82.00 ± 0.00^b	406.00 ± 0.00^a
Fat, g	1.30 ± 0.00^b	6.30 ± 0.00^a
Carbohydrate, g	16.50 ± 0.00^b	78.20 ± 0.00^a
Protein, g	1.00 ± 0.00^b	9.10 ± 0.00^a
Ash, %w/w	5.50 ± 0.00^a	2.70 ± 0.00^b
Moisture, %w/w	75.70 ± 0.00^a	3.70 ± 0.00^b
Insoluble fibre %w/w	5.10 ± 0.00^b	55.00 ± 0.28^a
Soluble fibre, %w/w	1.50 ± 0.00^b	8.60 ± 0.00^a
Total dietary fiber, %w/w	6.60 ± 0.00^b	63.60 ± 0.28^a
Vitamin C, mg/100 g	5.90 ± 0.00^a	0.70 ± 0.00^b
Potassium, mg/100 g	48.40 ± 0.28^b	79.00 ± 0.28^a
Magnesium, mg/100 g	9.80 ± 0.00^b	59.00 ± 0.28^a

Means within column with the same letter are not significantly different at p >0.05
PGC = Pickled guava core

The fatty acid profile analysis in *Table 2* showed that the PGC-powder contained linoleic acid (5.0%), oleic acid (0.7%) and linolenic acid (0.10%). The consumption of these unsaturated fatty acids might help to decrease the risk of heart disease. Furthermore, the linoleic and linolenic acid is essential for human growth (Vaclavik et al., 2008). In the Malaysian context, basic daily essential fatty acid (EFA) requirement is 3% kcal (about 6.7 g) of omega-6 linoleic acid and 0.3% kcal omega-3 fatty acid based on a 2,000-kcal diet (Malaysia, 2005). The presence of linoleic acid in PGC-powder is in agreement with the findings by Uchôa-thomaz et al. (2014) whom reported that 77.35% of linoleic acid was found in guava seed powder. However, the amount of linoleic acid found in this study was far lower than the results obtained from the other studies (Arain et al. 2017; Habib 1986; Opute 1978; Uchôa-thomaz et al., 2014). The difference might result from the different variety used, agronomic practices, amount of heating used to dry the seed, and destroyed linoleic acid from prolong immersion in sodium-saturated brine. However, there is yet evidence and literature support regarding the last reason. The guavas used by Arain et al. (2017) were obtained from Pakistan, Uchôa-thomaz et al. (2014) used guava of cv. Paluma planted in Brazil, Habib (1986) obtained his guava from Egypt, and Opute (1978) sourced his guava from West Africa. Other fatty acids found in PGC-powder were palmitic acid (0.6%) and stearic acid (0.4%). The same type of saturated fatty acid was found in the powder produced from frozen guava fruit pulp in Brazil (Uchôa-thomaz et al. 2014).

Table 2. Fatty acid profile of powder produced from PGC

Fatty acid (%)	Results (mean)
Linoleic acid (n-6)	5.0
Oleic acid (n-9)	0.7
Palmitic acid (C16:0)	0.6
Stearic acid (C18:0)	0.4
Linolenic acid (C18:3)	0.1

PGC = Pickled guava core

Table 3. Nutrients comparison between GCP and commercial condiment powder

Parameters	Results (mean ± SD)	
	Control	GCP
Energy,kcal	326.00 ± 0.00^{d}	348.00 ± 1.41^{b}
Fat,g	0.00 ± 0.00^{c}	2.70 ± 0.14^{b}
Carbohydrate,g	80.70 ± 0.00^{a}	77.20 ± 0.00^{b}
Protein,g	0.90 ± 0.00^{d}	3.90 ± 0.14^{c}
Ash, %w/w	15.00 ± 0.00^{a}	13.60 ± 0.14^{b}
Moisture,%w/w	3.40 ± 0.00^{b}	2.60 ± 0.14^{c}
Insoluble fibre,%w/w	1.90 ± 0.00^{d}	29.20 ± 0.14^{b}
Soluble fibre,%w/w	1.70 ± 0.00^{d}	2.90 ± 0.14^{c}
Total fibre, %w/w	3.60 ± 0.00^{d}	32.10 ± 0.14^{b}

Means within column with the same letter are not significantly different at $p > 0.05$. GCP = Guava condiment powder

Guava condiment powder (GCP)

The analysis showed that GCP contained higher ($p < 0.05$) energy, fat, fibre and protein than the commercial powder (*Table 3*), strongly indicating that GCP had more nutrient than the commercial sample. The fat content in GCP indicated the presence of fatty acids. However, high heat exposure may significantly reduce the fat quality content in guava seeds (Chang et al., 2014).

Besides that, GCP is predicted to be more stable in terms of quality and shelf life due to the lower moisture content. Protein was significantly higher ($p < 0.05$) in GCP while only a small amount was found in the commercial sample. According to Uchôa-thomaz et al. (2014), seed protein has the potential as a food ingredient as well as a good alternative source of protein for the food processing industry. The high amount of fibre found in GCP has partly contributed to its higher content of carbohydrate.

Food with high dietary fibre can help to prevent constipation, promote weight lost, and decrease blood cholesterol and heart disease (BeMiller 2008).

Sensory evaluation

There was significant difference (p <0.05) between GCP and commercial sample for all five sensory attributes as presented in *Table 4*. The colour and taste for GCP was less preferred by panelists (p <0.05) than the commercial sample. The taste of GCP was slightly disliked by panelists due to its sandy texture. This explanation was included in the result of texture attribute, in which the score given by the panelists was neither like nor dislike (p <0.05). The overall acceptability attribute indicated that GCP was neither liked nor disliked by the panelists. Though GCP contains functional nutrients that are good for the digestive system, the consumer's acceptance greatly depends on the strength of impersonal and personal sources of information towards the particular functional food products (Hassan and Mustapha 2010).Hence, the product information and media promotion have to be effective in order to gain consumers' trusts that GCP has more nutritional value than the commercially available condiment powder.

Conclusion

PGC-powder is high in dietary fibre with significant amount of protein and unsaturated fat that can be further exploited as a potential food ingredient. The essential fatty acids in PGC-powder are beneficial to human health. The GCP contains higher nutritive value than the commercial condiment powder, contributing to a healthy function of human digestive system. This study has proven that pickled guava waste can be reprocessed into profitable food ingredients with a proper processing technique. Hence, further research on PGC-powder is necessary to identify more potential of PGC-powder either in clinical or food technology.

Table 4. Sensory preference test for GCP and commercial

Product	Colour	Odour	Taste	Texture	Overall acceptability
GCP	4.69 ± 1.38^{b}	4.72 ± 1.50^{b}	3.76 ± 1.61^{b}	4.74 ± 1.55^{b}	4.13 ± 1.61^{b}
Control	6.09 ± 0.77^{a}	6.12 ± 0.74^{a}	6.20 ± 0.94^{a}	6.05 ± 1.04^{a}	6.27 ± 0.90^{a}

Means within column with the same letter are not significantly different at p >0.05. N = 110
GCP = Guava condiment

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