CHAPTER 8

VALORIZATION OF KENAF SEEDS AS POTENTIAL FOOD INGREDIENT WITH HEALTH BENEFITS

Gita Addelia NEVARA[1.2]*, Sharifah Kharidah Syed MUHAMMAD[1], Norhasnida ZAWAWI[1], Nor Afizah MUSTAPHA[3], Roselina KARIM[3]

*Corresponding Author: gitanevara@gmail.com

DOI: https://dx.doi.org/10.5281/zenodo.10841254

[1]Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
https://orcid.org/0000-0002-2530-6212
https://orcid.org/0000-0002-9908-1503
https://orcid.org/0000-0001-7459-5025
[1]Department of Nutrition, Universitas Mohammad Natsir Bukittinggi, Jalan Tan Malaka Bukit Cangang, Bukittinggi 26136, Sumatera Barat, Indonesia
[3]Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

https://orcid.org/0000-0002-0891-9738
https://orcid.org/0000-0003-0105-6666

ABSTRACT

Originating from kenaf seed, kenaf seed gum (KSG) is an innovative seed gum candidate. The health benefits of KSG were assessed in comparison to those of commercial guar gum (GG) and locust bean gum (LBG), with regards to their bio-functional and antioxidant properties. The cholesterol and bile salt binding capacities of KSG were 7.01 mg/g and 82.58% which were comparable to commercial seed gums. However, KSG revealed lower glucose absorption capacity compared to commercial GG and LBG. In addition, the antioxidant properties of the KSG were comparable to those of commercial seed gums, as measured by Ferric Reducing Antioxidant Power (FRAP) and DPPH radical scavenging activity. This research offers fundamental insights that can be utilized to investigate the potential of KSG as an unconventional seed gum, particularly in the food industry.

Keywords: guar gum, *Hibiscus cannabinus*, kenaf seed, locust bean gum.

8.1. Introduction

In the food, pharmaceutical, and cosmetics sectors, gums are water-soluble polysaccharides. Because of their accessibility, affordability, and advantageous properties, seed gums are widely utilized in the production of commercial hydrocolloids (Naji et al., 2012; Niknam et al., 2018). The distinctive physical and chemical characteristics of seed gums define their function as emulsifiers, stabilizers, and thickeners (Vilaró et al., 2018). Commercial applications frequently utilize guar gum (GG) and locust bean gum (LBG) as seed gums on account of their viscosity characteristics (BeMiller, 2019). Particularly for the production of novel food items that offer health benefits and a pleasant flavor, the food industry has a significant demand for seed gums (Douaire & Norton, 2013).

Koocheki et al. (2022); Qian et al. (2012); Razavi et al. (2014) have documented a multitude of methods for the isolation of seed gums derived from diverse sources. The physicochemical attributes of gums can be affected by the extraction and purification methods used (Rashid et al., 2018). Furthermore, in addition to the physicochemical attributes, a substantial understanding of the functional and antioxidant properties of the seed gum is required when they are incorporated into food systems. This is due to the fact that their interactions with other components can significantly alter the microstructure and properties of the end food products (Alba et al., 2018).

As a cordage commodity, kenaf (*Hibiscus cannabinus* L.) has been utilized primarily for many years (Monti, 2013). On a global scale, this natural fiber holds significant importance owing to its adaptability to diverse weather conditions (Akinrotimi & Okocha, 2018) and its extensive utilization in industry, including but not limited to paper and pulp production, textile manufacturing, bio-composites, insulation mat development, and absorption material production (Monti, 2013). Presently, it is cultivated in numerous tropical and subtropical nations across the globe (Mariod et al., 2017).

After harvesting, kenaf seeds, which are a by-product of kenaf plant production, are frequently discarded (Chan et al., 2013). Replanting utilizes a mere 2% of the seedlings that are produced (Wei, 2019). Potential food industry constituents include kenaf seeds, which are rich in fat, protein, and fiber (Ibrahim et al., 2019; Karim et al., 2020). Kenaf seed applications are the subject of an expanding body of research, which includes kenaf seed oil (Chan & Ismail, 2009; Monti, 2013; Yazan et al., 2011), defatted kenaf seed meal (Chan et al., 2013), milk and tofu derived from kenaf (Ibrahim et al., 2020; Karim et al., 2020) and kenaf seed protein concentrates (Ibrahim et al., 2021; Mariod et al., 2010). Recently, a study on the physicochemical attributes of KSG has been conducted (Nevara et al., 2022).

Converting kenaf seed into a valuable compound would benefit the environment and food security. Due to limited information on kenaf seed gum (KSG), which could be a valuable, low-cost seed gum source for the food industry, research on health benefits of KSG is crucial. Therefore, this work aims to examine the bio-functional and antioxidant properties of KSG and compare them to the commonly used seed gums (GG and LBG) to demonstrate the potential of KSG as a novel gum.

8.2. Methods

1. Raw materials

Kenaf (*Hibiscus cannabinus* L.) seeds variety V36 were kindly donated by The National Kenaf and Tobacco Board (LKTN) located in Kangar, Perlis, Malaysia. The seeds underwent precleansing to eliminate larger contaminants, including dust, chaff, stones, and immature seeds, prior to being washed. Three times under flowing tap water, the seeds were rinsed. Following that, they underwent a five-hour drying process in an oven set at 40°C. Until subsequent use, the seeds were stored at room temperature (25±2°C) after being sealed in plastic bags. Commercial guar gum (G4129) and locust bean gum from *Cerratonia siliqua* seeds (G0753) were purchased from Sigma-Aldrich (USA).

2. Kenaf seed gum extraction

The extraction and purification of KSG were conducted based on the prior investigation (Nevara et al., 2022). The extraction method is shown in Figure 8.1.

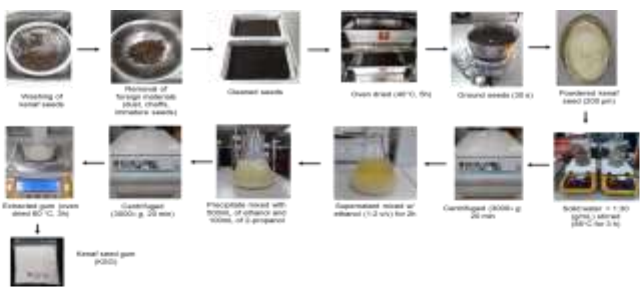

Figure 8.1. Extraction of kenaf seed gum

8.3. Yield of kenaf seed gum

It was discovered that the yield of KSG extracted from kenaf seeds could reach 21.13%. A similar rate of yield, 22%, was documented for fenugreek seeds in a study by Brummer et al. (2003). On the contrary, the yield of KSG was found to be greater than that of several other seed gums, including *Prosopis spp.* (14.2%) (López-Franco et al., 2013), *Lepidium sativum* (3.50–8.97%) (Razmkhah et al., 2016), *Prosopis juliflora* (16%) (Azero & Andrade, 2002), and *Ipomoea turpethum* seeds (23%) (Singh et al., 2003).

The variations in the yields may be explained by biological and developmental factors, including species, seed origin, or endosperm development stage (Estévez et al., 2004). Furthermore, the variability in yield may also be impacted by the solvent composition, processing conditions, and the extraction method employed (Oliva et al., 2010).

8.4. Bio-functional properties of kenaf seed gum

Table 8.1 shows the glucose, cholesterol, and bile salt absorption capacities of KSG compared to as commercial gums such as GG and LBG.

Table 8.1. Bio-functional properties of KSG, GG, and LBG

Parameters	KSG	GG	LBG
Glucose absorption capacity (mg/g)	42.05 ± 0.89^{b}	53.89 ± 2.07^{a}	50.99 ± 1.59^{a}
Cholesterol absorption capacity (mg/g)	7.01 ± 0.06^{a}	6.76 ± 0.01^{b}	6.90 ± 0.09^{ab}
Bile salt binding capacity (%)	82.58 ± 0.49^{a}	83.30 ± 1.27^{a}	57.61 ± 1.33^{b}

Note: Each value is the means of three independent measurements. Significant differences ($p \leq .05$) were indicated by different letters in the same row. KSG = Kenaf Seed Gum; GG = Guar Gum; LBG = Locust Bean Gum

1. Glucose absorption capacity (GAC)

A notable difference in GAC was observed between KSG and commercial gums (Table 8.1). The highest GAC value was found in GG (53.89 mg/g), followed by LBG (50.99 mg/g) and KSG (42.05 mg/g). The GAC analysis indicates the hyperglycaemic effect in vitro of the studied seed gums. The results showed that commercial GG and LBG had higher GAC values than KSG. It may be attributed to their water absorption and gel-forming properties, which slow gastric emptying and increase satiation (Mudgil et al., 2014). The GAC of plant fibre defines the ability to bind glucose at low concentrations and slow its transport through the intestinal lumen (Bhinge et al., 2017). It reduces postprandial hyperglycaemia by inhibiting α-glucosidase and α-amylase (El-

Beshbishy & Bahashwan, 2012; Lim & Loh, 2016). Furthermore, foods containing guar gum reduced the desire to eat, appetite, and hunger (Butt et al., 2007).

3. Cholesterol absorption capacity (CAC)

The findings indicated that the CAC of KSG differed significantly ($p \leq .05$) from that of GG but was comparable to that of LBG (Table 1). KSG had the highest CAC (7.01 mg/g), followed by LBG (6.90 mg/g) and GG (6.76 mg/g). The study demonstrates the cholesterol-lowering effects of non-conventional seed gum (KSG). Cholesterol-lowering effects are often associated with edible thickening agents such as GG (Butt et al., 2007; Sharma et al., 2018).

The mechanism is related to increased bile acids excretion in faeces and reduced enterohepatic bile acid, which can stimulate bile acids production from cholesterol. Consequently, the concentration of liver free cholesterol decreases (Rideout et al., 2008). The KSG showed the highest CAC value, indicating its ability to absorb cholesterol. Furthermore, it has been closely related to reducing cardiovascular risk (Nsor-Atindana et al., 2012).

4. Bile salt binding capacity (BSBC)

Bile acid functions as a precursor to cholesterol. Bile acid can be absorbed by gums in the small intestine and subsequently excreted (Qiao et al., 2021). Bile acid absorption promotes the conversion of cholesterol to bile acid, hence reducing total cholesterol levels and the risk of cardiovascular disease (Zhu et al., 2018). Therefore, gums may have physiological activities that reduce blood fat levels. Over 90% of bile acids in the body are inbound forms (especially sodium salts). Therefore, sodium cholate hydrate was replaced with bile acid to determine the BSBC of the gums.

Table 8.2 showed that KSG had comparable BSBC with GG with 82.58% and 83.30%, respectively and both these values were significantly ($p \leq .05$) higher than in LBG. According to a study by Kim & Kim (2017), the BSBC of β-glucan isolated from various varieties of Jeju barley was approximately 25%. The findings of current study reveal a considerably higher BSBC value compared to the values reported for β-glucan extracted from Jeju barley. This suggests that KSG exerts a more pronounced hypocholesterolemia effect.

8.5. Antioxidant properties of kenaf seed gum

Table 8.2 showed the antioxidant properties of KSG compared with GG and LBG. Phenolics play a significant role in enhancing the body's antioxidant capacity. Thereby reducing the risk of chronic diseases caused by excessive free radicals (Jin et al., 2018).

Table 8.2. Antioxidant properties of KSG, GG, and LBG

Parameters	KSG	GG	LBG
Total phenolic content (mg GAE/g)	0.053 ± 0.002 [a]	0.014 ± 0.001 [b]	0.016 ± 0.000 [b]
DPPH radical scavenging activity (µM TE)	126.69 ± 2.30 [a]	128.88 ± 1.27 [a]	126.79 ± 1.51 [a]
ABTS radical scavenging activity (µM TE)	13.98 ± 0.08 [b]	14.44 ± 0.24 [a]	14.52 ± 0.24 [a]

Note: Each value is the means of three independent measurements. Significant differences (p ≤ .05) were indicated by different letters in the same row. KSG = Kenaf Seed Gum; GG = Guar Gum; LBG = Locust Bean Gum

In Table 8.2, the determination of TPC of gums revealed that KSG exhibited the highest phenolic content (0.053 mg GAE/g), which was significantly higher (p ≤ .05) than LBG (0.016 mg GAE/g) and GG (0.014 mg GAE/g). The lower phenolic content of GG and LBG in the current study is consistent with a Hamdani and Wani (2017) who studied composition of GG and LBG. The variation in TPC values could be attributed to the seed coat, as KSG was extracted from whole kenaf seeds, while commercial seed gums were primarily extracted from dehulled seeds. The seed coat of pigmented seeds, which comprises an estimated 10% of the total seed weight, is more abundant in phenolic compounds than that of light-colored seeds, which have a lower TPC (Singh et al., 2017). Furthermore, Segev et al. (2010) reported that coloured chickpea seeds had up to 13 times more TPC than beige and regular cream coloured seeds, indicating their potential as functional food sources.

According to Ma et al. (2013), lipid oxidation generates highly active free radicals, which can promote the transformation of normal cells into cancer cells in the human body. Gums can eliminate free radicals from the human body, so the antioxidant capability is crucial to determine its worth (Jin et al., 2018). Three of the most commonly used methods were selected to estimate various antioxidant capabilities. Radical scavenging ability was determined using DPPH and ABTS assays, while ferric-reducing adsorption capacity was assessed using the FRAP assay (Thaipong et al., 2006).

The results obtained using three different methods are shown in Table 8.2. The results showed that KSG (126.69 µM TE) has a comparable DPPH radical scavenging activity to that of GG (128.88 µM TE) and LBG (126.79 µM TE).

The electron donation or release of hydrogen to free radicals by different hydroxyl groups in the gum structure, which subsequently terminates the radical chain reaction, could potentially be the principal mechanism by which gums exert this activity (Kia & Ganjloo, 2018; Yang et al., 2016). On the contrary, the ABTS radical scavenging activity of the gums showed significant differences ($p \leq .05$), with KSG (13.98 μM TE) exhibiting lower activity than GG (14.44 μM TE) and LBG (14.52 μM TE). This could be attributed to the gum extraction pre-treatment, which involved washing and drying the kenaf seeds prior to extraction. These procedures may lead to the loss of water-soluble antioxidants, resulting in a reduction in their antioxidant activity (Jin et al., 2018). FRAP assays assess the reducing power (Benzie & Strain, 1999) and antioxidant capacity of the sample through chain breaking (Ghiselli et al., 1995).

In principle, at an acidic pH, the iron complex of tripyridyltriazine is essentially reduced from $Fe(TPTZ)^{3+}$ to $Fe(TPTZ)^{2+}$. The reduction to an intensely blue reaction mixture is accompanied by a colour change that can be quantified spectrophotometrically (Hamdani & Wani, 2017). KSG and GG showed comparable reducing power with 0.006 μM TE and 0.004 μM TE, respectively, more significant than LBG (0.002 μM TE) (Table 2). The result revealed that KSG has the ability to donate electrons to react with free radicals and convert them into stable molecules (Kia & Ganjloo, 2018). The reducing power of seed gums in the current study was in agreement with the previous research on coloured chickpeas (Segev et al., 2010).

8.6. Conclusion

Carbohydrate-protein gum was extracted from kenaf seed using an aqueous extraction method with a yield of 21.0%. The mixture of protein and polysaccharides in KSG resulted in health beneficial properties to those of commercial GG and LBG. KSG demonstrated comparable cholesterol and bile salt binding capacity, but lower glucose absorption capacity compared to commercial GG and LBG. In terms of antioxidant properties, KSG had higher TPC for antioxidant properties, but similar antioxidant activity with GG and LBG, except for ABTS radical scavenging activity. This study provides information on a novel KSG to support future potential applications of KSG in the food industries.

8.7. Recommendation

More studies on various aspects of kenaf seed gum are recommended in the future. These include: (i) Comparison of innovative, sustainable and green extraction techniques (e.g., ultrasonic microwave assisted extraction) on kenaf seed gum versus conventional solvent extraction method; (ii) Effect of fortification on food quality; (iii) Functional properties in various food applications; and (iv) Stability and shelf life in food products.

REFERENCES

Ahmed, J., Thomas, L., & Arfat, Y. A. (2019). Functional, rheological, microstructural and antioxidant properties of quinoa flour in dispersions as influenced by particle size. *Food Research International*, *116*, 302–311. https://doi.org/10.1016/j.foodres.2018.08.039

Akinrotimi, C. A., & Okocha, P. I. (2018). Evaluations of genetic divergence in kenaf (*Hibiscus cannabinus* L.) genotypes using agro-morphological characteristics. *Journal of Plant Science and Agricultural Research*, *2*, 1–10.

Alba, K., MacNaughtan, W., Laws, A. P., Foster, T. J., Campbell, G. M., & Kontogiorgos, V. (2018). Fractionation and characterisation of dietary fibre from blackcurrant pomace. *Food Hydrocolloids*, *81*, 398–408. https://doi.org/10.1016/j.foodhyd.2018.03.023

Azero, E. G., & Andrade, C. T. (2002). Testing procedures for galactomannan purification. *Polymer Testing*. https://doi.org/10.1016/S0142-9418(01)00123-4

BeMiller, J. N. (2019). Guar, Locust Bean, Tara, and Cassia Gums. In *Carbohydrate Chemistry for Food Scientists* (pp. 241–252). Elsevier Inc. https://doi.org/10.1016/b978-0-12-812069-9.00009-1

Benzie, I. F. F., & Strain, J. J. (1999). Ferric reducing/antioxidant power assay: Direct measure of total antioxidant activity of biological fluids and modified version for simultaneous measurement of total antioxidant power and ascorbic acid concentration. *Methods in Enzymology*, *299*(1995), 15–27. https://doi.org/10.1016/S0076-6879(99)99005-5

Bhinge, S. D., Bhutkar, M. A., Randive, D. S., Wadkar, G. H., & Hasabe, T. S. (2017). In vitro hypoglycemic effects of unripe and ripe fruits of Musa sapientum. *Brazilian Journal of Pharmaceutical Sciences*, *53*(4), 1–6. https://doi.org/10.1590/s2175-97902017000400159

Brummer, Y., Cui, W., & Wang, Q. (2003). Extraction, purification and physicochemical characterization of fenugreek gum. *Food Hydrocolloids*, *17*(3), 229–236. https://doi.org/10.1016/S0268-005X(02)00054-1

Butt, M. S., Shahzadi, N., Sharif, M. K., & Nasir, M. (2007). Guar gum: A miracle therapy for hypercholesterolemia, hyperglycemia and obesity. *Critical Reviews in Food Science and Nutrition*, *47*(4), 389–396. https://doi.org/10.1080/10408390600846267

Chan, K. W., & Ismail, M. (2009). Supercritical carbon dioxide fluid extraction of *Hibiscus cannabinus* L. seed oil: A potential solvent-free and high antioxidative edible oil. *Food Chemistry*, *114*(3), 970–975. https://doi.org/10.1016/j.foodchem.2008.10.055

Chan, K. W., Khong, N. M. H., Iqbal, S., Mansor, S. M., & Ismail, M. (2013). Defatted kenaf seed meal (DKSM): Prospective edible flour from agricultural waste with high antioxidant activity. *LWT - Food Science and Technology*, *53*(1), 308–313. https://doi.org/10.1016/j.lwt.2013.01.003

Douaire, M., & Norton, I. T. (2013). Designer colloids in structured food for the future. *Journal of the Science of Food and Agriculture*, *93*(13), 3147–3154. https://doi.org/10.1002/jsfa.6246

El-Beshbishy, H. A., & Bahashwan, S. A. (2012). Hypoglycemic effect of basil (Ocimum basilicum) aqueous extract is mediated through inhibition of α-glucosidase and α-amylase activities: An in vitro study. *Toxicology and Industrial Health*, *28*(1), 42–50. https://doi.org/10.1177/0748233711403193

Estévez, A. M., Sáenz, C., Hurtado, M. L., Escobar, B., Espinoza, S., & Suárez, C. (2004). Extraction methods and some physical properties of mesquite (Prosopis chilensis (Mol) Stuntz) seed gum. *Journal of the Science of Food and Agriculture*, *84*(12), 1487–1492. https://doi.org/10.1002/jsfa.1795

Ghiselli, A., Serafini, M., Maiani, G., Azzini, E., & Ferro-Luzzi, A. (1995). A fluorescence-based method for measuring total plasma antioxidant capability. *Free Radical Biology and Medicine*, *18*(1), 29–36. https://doi.org/10.1016/0891-5849(94)00102-P

Hamdani, A. M., & Wani, I. A. (2017). Guar and Locust bean gum : Composition , total phenolic content , antioxidant and antinutritional characterisation. *Bioactive Carbohydrates and Dietary Fibre*, *11*(July), 53–59. https://doi.org/10.1016/j.bcdf.2017.07.004

Ibrahim, Shafa'atu Giwa, Ibadullah, W. Z. W., Saari, N., & Karim, R. (2021). Functional properties of protein concentrates of KB6 kenaf (*Hibiscus cannabinus*) seed and its milky extract. *LWT - Food Science and Technology*, *135*, 110234. https://doi.org/10.1016/j.lwt.2020.110234

Ibrahim, Shafa'atu Giwa, Karim, R., Saari, N., Abdullah, W. Z. W., Zawawi, N., Razak, A. F. A., Hamim, N. A., & Umar, R. A. (2019). Kenaf (*Hibiscus cannabinus* L.) seed and its potential food applications: A Review. *Journal* *of Food Science*, *84*(8), 2015–2023. https://doi.org/10.1111/1750-3841.14714

Ibrahim, Shafa'atu Giwa, Mat Noh, N. A., Wan Ibadullah, W. Z., Saari, N., & Karim, R. (2020). Water soaking temperature of kenaf (*Hibiscus cannabinus* L.) seed, coagulant types, and their concentrations affected the production of kenaf-based tofu. *Journal of Food Processing and Preservation*, *44*(7), 1–13. https://doi.org/10.1111/jfpp.14549

Jin, Q., Xie, F., Luo, J., Huang, X., Wen, J., Zhang, W., Wu, J., He, J., & Wang, Z. (2018). Investigation of Functional and Structural Properties of Insoluble Dietary Fiber From Sichuan Natural Fermented Pickles With Different Salting Treatments. *Starch - Stärke*, *70*(9–10), 1800047. https://doi.org/10.1002/star.201800047

Karim, R., Noh, N. A. M., Ibrahim, S. G., Ibadullah, W. Z. W., Zawawi, N., & Saari, N. (2020). Kenaf (*Hibiscus cannabinus* L.) Seed Extract as a New Plant-Based Milk Alternative and Its Potential Food Uses. In M. Ziarno (Ed.), *Milk Substitutes* (pp. 1–13). IntechOpen. https://doi.org/10.5772/intechopen.94067

Kia, A. G., & Ganjloo, A. (2018). A Short Extraction Time of Polysaccharides from Fenugreek (Trigonella foencem graecum) Seed Using Continuous Ultrasound Acoustic Cavitation: Process Optimization, Characterization and Biological Activities. *Food and Bioprocess Technology*, *11*, 2204–2216. https://doi.org/https://doi.org/10.1007/s11947-018-2178-2

Kim, H. J., & Kim, H. J. (2017). Physicochemical characteristics and in vitro bile acid binding and starch digestion of β-glucans extracted from different varieties of Jeju barley. *Food Science and Biotechnology*, *26*(6), 1501–1510. https://doi.org/10.1007/s10068-017-0153-8

Koocheki, A., Hesarinejad, M. A., & Mozafari, M. R. (2022). Lepidium perfoliatum seed gum: investigation of monosaccharide composition, antioxidant activity and rheological behavior in presence of salts. *Chemical and Biological Technologies in Agriculture*, *9*(1), 1–14. https://doi.org/10.1186/s40538-022-00322-2

Lim, S. M., & Loh, S. P. (2016). In vitro antioxidant capacities and antidiabetic properties of phenolic extracts from selected citrus peels. *International Food Research Journal*, *23*(1), 211–219.

López-Franco, Y. L., Cervantes-Montaño, C. I., Martínez-Robinson, K. G., Lizardi-Mendoza, J., & Robles-Ozuna, L. E. (2013). Physicochemical characterization and functional properties of galactomannans from mesquite seeds (Prosopis spp.). *Food Hydrocolloids*, *30*(2), 656–660. https://doi.org/10.1016/j.foodhyd.2012.08.012

Ma, Y., Zhang, L., Rong, S., Qu, H., Zhang, Y., Chang, D., Pan, H., & Wang, W. (2013). Relation between gastric cancer and protein oxidation, DNA damage, and lipid peroxidation. *Oxidative Medicine and Cellular Longevity*, *2013*, 1–6. https://doi.org/10.1155/2013/543760

Mariod, A. A., Fathy, S. F., & Ismail, M. (2010). Preparation and characterisation of protein concentrates from defatted kenaf seed. *Food Chemistry*, *123*(3), 747–752. https://doi.org/10.1016/j.foodchem.2010.05.045

Mariod, A. A., Saeed Mirghani, M. E., & Hussein, I. (2017). *Hibiscus cannabinus* L. Kenaf. In *Unconventional Oilseeds and Oil Sources* (pp. 45–51). Elsevier. https://doi.org/10.1016/B978-0-12-809435-8.00009-3

Monti, A. (2013). *Kenaf: A Multi-Purpose Crop for Several Industrial Applications* (A. Monti & E. Alexopoulou (eds.)). Springer Verlag. https://doi.org/10.1007/978-1-4471-5067-1

Mudgil, D., Barak, S., & Khatkar, B. S. (2014). Guar gum: Processing, properties and food applications - A Review. *Journal of Food Science and Technology*, *51*(3), 409–418. https://doi.org/10.1007/s13197-011-0522-x

Nevara, Gita Addelia, Muhammad, S. K. S., Zawawi, N., Mustapha, N. A., & Karim, R. (2022). Physicochemical and functional properties of carbohydrate–protein gum extracted from kenaf (*Hibiscus cannabinus* L.) seed. *International Journal of Food Science & Technology*, *57*(1), 258–267. https://doi.org/10.1111/ijfs.15421

Nsor-Atindana, J., Zhong, F., & Mothibe, K. J. (2012). In vitro hypoglycemic and cholesterol lowering effects of dietary fiber prepared from cocoa (Theobroma cacao L.) shells. *Food and Function*, *3*(10), 1044–1050. https://doi.org/10.1039/c2fo30091e

Oliva, M., Alfaro, C., & Palape, I. (2010). Evaluation of the technological potential of galactomannans from the endosperm of seeds of Prosopis sp. for use in the food industry. *AgriScientia*, *27*(2), 107–113. https://revistas.unc.edu.ar/index.php/agris/article/view/2772

Qian, K. Y., Cui, S. W., Wu, Y., & Goff, H. D. (2012). Flaxseed gum from flaxseed hulls: Extraction, fractionation, and characterization. *Food Hydrocolloids*, *28*(2), 275–283. https://doi.org/10.1016/j.foodhyd.2011.12.019

Qiao, C.-C., Zeng, F.-K., Wu, N.-N., & Tan, B. (2021). Functional, physicochemical and structural properties of soluble dietary fiber from rice bran with extrusion cooking treatment. *Food Hydrocolloids*, *121*, 107057. https://doi.org/10.1016/j.foodhyd.2021.107057

Rashid, F., Hussain, S., & Ahmed, Z. (2018). Extraction purification and characterization of galactomannan from fenugreek for industrial utilization. *Carbohydrate Polymers*, *180*, 88–95. https://doi.org/10.1016/j.carbpol.2017.10.025

Razavi, S. M. A., Cui, S. W., Guo, Q., & Ding, H. (2014). Some physicochemical properties of sage (Salvia macrosiphon) seed gum. *Food Hydrocolloids*. https://doi.org/10.1016/j.foodhyd.2013.06.022

Razmkhah, S., Mohammadifar, M. A., Razavi, S. M. A., & Ale, M. T. (2016). Purification of cress seed (Lepidium sativum) gum: Physicochemical characterization and functional properties. *Carbohydrate Polymers*, *141*, 166–174. https://doi.org/10.1016/j.carbpol.2015.12.071

Rideout, T. C., Harding, S. V., Jones, P. J. H., & Fan, M. Z. (2008). Guar gum and similar soluble fibers in the regulation of cholesterol metabolism: Current understandings and future research priorities. *Vascular Health and Risk Management*, *4*(5), 1023–1033. https://doi.org/10.2147/vhrm.s3512

Segev, A., Badani, H., Kapulnik, Y., Shomer, I., Oren-Shamir, M., & Galili, S. (2010). Determination of Polyphenols, Flavonoids, and Antioxidant Capacity in Colored Chickpea (Cicer arietinum L.). *Journal of Food Science*, *75*(2), 2–6. https://doi.org/10.1111/j.1750-3841.2009.01477.x

Sharma, P., Bhandari, C., Kumar, S., Sharma, B., Bhadwal, P., & Agnihotri, N. (2018). Dietary Fibers: A Way to a Healthy Microbiome. In *Diet, Microbiome and Health* (pp. 1–22). Elsevier Inc. https://doi.org/10.1016/B978-0-12-811440-7/00011-9

Singh, B., Singh, J. P., Kaur, A., & Singh, N. (2017). Phenolic composition and antioxidant potential of grain legume seeds: A review. *Food Research International*, *101*, 1–16. https://doi.org/10.1016/j.foodres.2017.09.026

Singh, V., Srivastava, V., Pandey, M., Sethi, R., & Sanghi, R. (2003). Ipomoea turpethum seeds: A potential source of commercial gum. *Carbohydrate Polymers*, *51*, 357–359. https://doi.org/10.1016/S0144-8617(02)00186-8

Thaipong, K., Boonprakob, U., Crosby, K., Cisneros-Zevallos, L., & Hawkins Byrne, D. (2006). Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts. *Journal of Food Composition and Analysis*, *19*(6–7), 669–675. https://doi.org/10.1016/j.jfca.2006.01.003

Vilaró, P., Bennadji, Z., Budelli, E., Moyna, G., Panizzolo, L., & Ferreira, F. (2018). Isolation and characterization of galactomannans from Prosopis affinis as potential gum substitutes. *Food Hydrocolloids*, *77*, 711–719. https://doi.org/10.1016/j.foodhyd.2017.10.038

Wei, C. K. (2019). *Cholesterol-lowering Properties of Defatted Kenaf Seed Meal and its Phenolics-Saponins-rich Extract in a Rat Model*. Universiti Putra Malaysia.

Yang, N., Jin, Y., Jin, Z., & Xu, X. (2016). Electric-Field-Assisted Extraction of Garlic Polysaccharides via Experimental Transformer Device. *Food and Bioprocess Technology*, *9*(9), 1612–1622. https://doi.org/10.1007/s11947-016-1742-x

Yazan, L. S., Foo, J. B., Ghafar, S. A. A., Chan, K. W., Tahir, P. M., & Ismail, M. (2011). Effect of kenaf seed oil from different ways of extraction towards ovarian cancer cells. *Food and Bioproducts Processing*, *89*(4), 328–332. https://doi.org/10.1016/j.fbp.2010.10.007

Zhu, Y., Chu, J., Lu, Z., Lv, F., Bie, X., Zhang, C., & Zhao, H. (2018). Physicochemical and functional properties of dietary fiber from foxtail millet (Setaria italic) bran. *Journal of Cereal Science*, *79*, 456–461. https://doi.org/10.1016/j.jcs.2017.12.011

Brief Curriculum Vitae

Gita Addelia Nevara, S.TP., M.Sc, Ph. D. born on 3 October 1988 in Silungkang, West Sumatera, Indonesia, is an accomplished food scientist and educator. She earned her Bachelor's degree in Food Technology from the Faculty of Agricultural Technology at Andalas University in 2011. Recognizing her passion for food science, she pursued her Master's degree in Food Science from the Faculty of Food Science and Technology at Universiti Putra Malaysia (UPM), and graduated in January 2016. During her Master's program, she was the recipient of an LPDP scholarship from the Ministry of Finance, Republic of Indonesia. Gita Addelia Nevara's academic achievements and commitment to food science and education led to her appointment as a lecturer in the Department of Nutrition at Universitas Mohammad Natsir Bukittinggi, Indonesia, in December 2017. She was passionate about sharing her knowledge and skills with her students, inspiring them to pursue their own careers in food science. In October 2019, Gita Addelia Nevara was awarded a joint full scholarship from DAAD (German Academic Exchange Service) and SEARCA (Southeast Asian Regional Centre for Graduate Study and Research in Agriculture) to pursue her Ph.D. in Food Science at UPM and graduated in 2023. Her dedication to research has been exemplary, as evidenced by the five publications she has successfully published during her Ph.D. program. In recognition of her outstanding research contributions, Gita Addelia Nevara was awarded two travel awards to present her research findings at an international conference in Cambodia and the World Food Congress in Singapore in 2022. In 2023, she was awarded DAAD Summer School Scholarship at the Heidelberg Institute of Global Health (HIGH), Heidelberg University, Germany. Gita Addelia Nevara's academic achievements, combined with her passion for food science and education, make her a valuable asset to the academic community. Her research and teaching are sure to have a positive impact on the food industry for years to come.

gitanevara@gmail.com. https://orcid.org/0000-0002-2530-6212. Scopus index: 4