Journal of Plant Biota

Original Research Article
ISSN: 3048-4863
Journal homepage: https://plant.researchfloor.org/

Coconut Testa as a Functional Food Ingredient: Proximate and Phytochemical Characterization for Nutraceutical Applications

Ramya H.N.[1], Roopith H. Chavan.[1], Ajaykumar M.[2] and Santosh Kumar S.R.*[1]

[1]*Department of Studies in Food Technology, Davangere University, Davanagere, Karnataka, India*
[2]*Department of Food Technology, Alva's Institute of Agricultural Sciences and Technology, Moodubidri, Karnataka, India*

Abstract

Coconut testa (CT), the thin brown outer skin of the coconut kernel, is a by-product of the coconut processing industry that is commonly discarded or used for low-grade oil and animal feed. This study characterised the proximate composition and the secondary metabolite profile of CT from fresh coconuts. Testa was separated, shade-dried, powdered and macerated in methanol. Proximate analysis showed that CT is predominantly an oil-rich material (fat 62.23 ± 0.54 %), with considerable carbohydrate (18.3 ± 0.28 %), crude fibre (11.8 ± 0.19 %) and protein (8.3 ± 0.14 %), and low ash (1.42 ± 0.06 %) and moisture (3.8 ± 0.23 %). Qualitative screening of the methanolic extract revealed an abundance of alkaloids, phenols, steroids and terpenoids, a moderate level of flavonoids, and trace amounts of saponins and tannins. Quantitative analysis at 500 and 1000 µg/mL showed concentration-dependent increases in all four metabolite classes measured: alkaloids (20.11 to 24.44 mg), flavonoids (0.32 to 1.09 mg/L), phenols (0.05 to 0.78 mg/mL) and terpenoids (13.40 to 22.60 mg). The results are consistent with earlier reports on CT and support its potential as a source of edible oil, dietary fibre and bioactive phytochemicals for value-added food, nutraceutical and cosmetic applications.

Keywords: *Bioactive compounds, nutraceuticals, antioxidant properties, waste utilization.*

1. Introduction

Coconut (*Cocos nucifera* L.) is one of the most widely used tropical crops, and almost every part of the palm has some human use. The most valuable component of the fruit is the white kernel, which is covered by a thin brown layer called the testa. Because the testa imparts a brown colour to processed products, it is customarily removed before the manufacture of items such as desiccated coconut and coconut milk powder [1]. A rough estimate suggests that around 6500 kg of testa may be generated from 100,000 nuts [2]. In practice the testa is undervalued: it is mainly used for extracting inferior-quality oil, while the defatted residue goes into animal feed [3]. A long-standing belief that the testa is unsafe for human consumption, because it acts as a protective layer and might contain toxic elements, has also limited its use as food [3].

Seed coats generally act as physical and biochemical barriers that protect the inner kernel and embryo from injury and microbial attack [4]. In coconut, the testa is a living tissue that undergoes physiological and biochemical changes as the fruit matures, turning from pale white in the tender nut to pale-brown or dark-brown at full maturity [3]. The testa is rich in phyto-nutrients including polyphenols, flavonoids, tannins and anthocyanins, which are linked to antioxidant, anti-hyperglycaemic, antimicrobial and anti-inflammatory activities [3,5,6]. Sterols, terpenoids, steroids and alkaloids have also been reported in the testa [3]. These properties have raised interest in using the testa and its by-products, such as testa oil and defatted testa flour, as ingredients with health benefits.

The proximate composition of CT has been reported to differ between studies. Dried testa was found to contain about 59 % fat, 26.3 % carbohydrate, 9.3 % protein, 11.6 % crude fibre and 1.4 % ash [7], whereas creamed testa was reported to contain 65.63 % fat, 16.00 % crude fibre, 8.11 % protein and 1.54 % ash [8]. Such differences are attributed to geographical origin, variety and processing [3]. In the same way, the phytochemical profile depends on the origin of the sample and on the extraction solvent, because plant secondary metabolites are responsible for much of the antioxidant activity of plant materials [9] and solvent polarity strongly affects extractability [6,10]. Quantitative data on the less-studied metabolite classes, such as alkaloids and terpenoids, remain limited compared with data on phenolics and flavonoids.

The aim of this study was therefore to determine the proximate composition of coconut testa and to screen and quantify selected secondary metabolites (alkaloids, flavonoids, phenols and terpenoids) in its methanolic extract, and to interpret the findings in light of the existing literature.

12 June 2026: Received | 14 July 2026: Revised | 13 August 2026: Accepted | 16 September 2026: Available Online

Citation: Ramya H.N., Roopith H. Chavan., Ajaykumar M. and Santosh Kumar S.R. (2026). Coconut Testa as a Functional Food Ingredient: Proximate and Phytochemical Characterization for Nutraceutical Applications. *Journal of Plant Biota.* **32 to 35.**
DOI: https://doi.org/10.51470/JPB.2026.5.2.32

Santosh Kumar S.R. | santoshkumarsr@davangereuniversity.ac.in

Copyright*: © 2026 by the authors. The license of Journal of Plant Biota. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).*

2. Materials and Methods

2.1 Sample Collection and Extract Preparation

Fresh coconuts were procured from a local market to ensure uniformity and washed thoroughly with distilled water to remove surface impurities. The thin brown testa layer was separated from the kernel using a sterilised knife, shade-dried for one week under ambient conditions to preserve heat-sensitive compounds and limit microbial contamination, then ground into a fine powder and stored in airtight containers. For extraction, 10 g of powdered testa was macerated in 100 mL of methanol for 48 hours at room temperature with occasional shaking. The mixture was filtered through Whatman No. 1 filter paper, and the filtrate was concentrated at 40 °C using a rotary evaporator. Extract yield was calculated on a dry-weight basis, and the concentrated extract was stored at 4 °C to preserve bioactive components until analysis.

2.2 Proximate Composition Analysis

The powdered testa was analysed for moisture, crude fat, crude protein, crude fibre, ash and carbohydrate using standard official procedures (AOAC). Moisture was determined by oven drying to constant weight, crude fat by Soxhlet extraction, crude protein by the Kjeldahl method (nitrogen × 6.25), crude fibre by acid and alkaline digestion, and ash by incineration in a muffle furnace. Carbohydrate content was determined by difference. All results are expressed as percentage (w/w) [11, 12, 13].

2.3 Qualitative Phytochemical Screening

The methanolic extract was screened for alkaloids, flavonoids, phenols, saponins, steroids, tannins and terpenoids using standard qualitative colour and precipitation tests Mayer's test for alkaloids, alkaline reagent test for flavonoids, ferric chloride test for phenols and tannins, froth test for saponins, Liebermann–Burchard test for steroids, Salkowski test for terpenoids [14,15,16]. The abundance of each class was recorded semi-quantitatively as + (present in trace amount), ++ (moderately present) or +++ (abundantly present).

2.4 Quantitative Phytochemical Analysis

Alkaloids, flavonoids, phenols and terpenoids were quantified in the extract at two concentrations (500 and 1000 µg/mL) gravimetric determination for alkaloids and terpenoids, aluminium chloride colorimetric assay for flavonoids and Folin–Ciocalteu assay for phenols [17,18].

2.5 Statistical Analysis

All determinations were carried out in replicate [n = 3, confirm], and results are presented as mean ± standard deviation (SD). Calculations were performed using Microsoft Excel 2019 and GraphPad Prism v9.

3. Results and Discussion

3.1 Proximate Composition

The proximate composition of the coconut testa is given in Fig. 1. Fat was the dominant constituent (62.23 ± 0.54 %), followed by carbohydrates (18.3 ± 0.28 %), crude fibre (11.8 ± 0.19 %) and protein (8.3 ± 0.14 %). Ash (1.42 ± 0.06 %) and moisture (3.8 ± 0.23 %) were minor components.

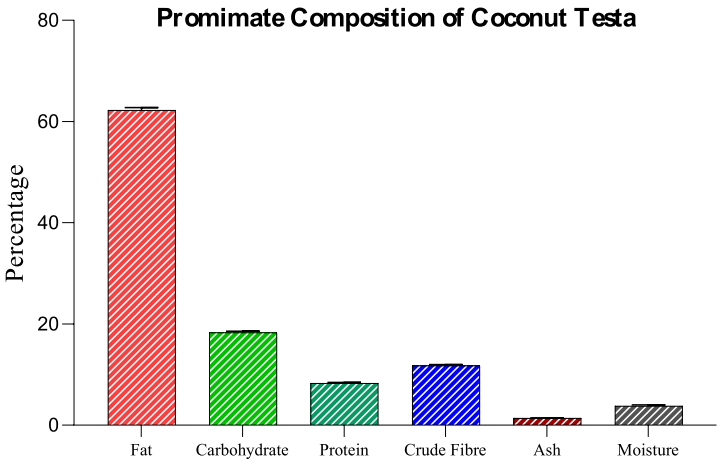


Fig. 1: Proximate composition of coconut testa

The high fat content places CT among oil-rich materials, which agrees with earlier reports of 59 % fat in dried testa [7] and 65.63 % in creamed testa [8]. The fat content found here lies between these two values. It is also far higher than that of rice bran (12.03–18.68 %) and wheat bran (4.25 %), as compiled in recent work [3,20,21], which reflects the unique structure of the coconut kernel and explains why testa is generally subjected to oil extraction [3]. The protein (8.3 %) and ash (1.42 %) values are very close to those reported previously (protein 8.11 % and 9.3 %; ash 1.54 % and 1.4 %) [7,8]. Crude fibre (11.8 %) was almost identical to the 11.6 % reported by Appaiah et al. [7] but lower than the 16.00 % reported for creamed testa [8]. The carbohydrate content (18.3 %) was lower than the 26.3 % reported for dried testa [7]. Differences of this kind are usually ascribed to geographical origin, varietal differences and the analytical or processing approach [3]. Defatted testa flour is known to be richer in carbohydrate (42.55–59.24 %) and protein (23.82–32.22 %), because removal of oil concentrates the remaining nutrients [19].

The low moisture content (3.8 %) is a favourable outcome of the one-week shade-drying step. Freshly disintegrated testa is wet, with a moisture content of 40 to 47 %, and delays in processing promote microbial growth and lipid oxidation, which lower the quality of the testa and of the oil extracted from it [3]. A dry, low-moisture powder is therefore easier to store, although the high lipid content still makes protection from oxidation important.

The fibre fraction is also relevant. Defatted testa flour has been reported to contain a high level of dietary fibre and has been incorporated into cookies, string hoppers and flat-bread [1, 3], so the fibre found in the whole testa is consistent with its interest as a food ingredient.

3.2 Qualitative Phytochemical Screening

The qualitative screening results for the methanolic extract are shown in Table 1. Alkaloids, phenols, steroids and terpenoids were abundantly present (+++), flavonoids were moderately present (++), and saponins and tannins were present only in trace amounts (+).

Table 1: Qualitative screening of secondary metabolites in coconut testa

Sample	Alkaloids	Flavonoids	Phenols	Saponins	Steroids	Tannins	Terpenoids
Coconut testa	+++	++	+++	+	+++	+	+++

(+ = present in trace amount, ++ = moderately present, +++ = abundantly present).

The abundance of phenols and the presence of flavonoids agree with the many reports that polyphenols and flavonoids are the major phytochemicals of coconut testa [3,5,6]. Methanolic extracts of testa from several Sri Lankan cultivars were found to be rich in polyphenols and flavonoids and to have the highest antioxidant and α-amylase inhibitory activities among the solvents tested [6]. Likewise, sequential Soxhlet extraction of testa has been shown to yield a wide range of phenolic and non-phenolic compounds [22]. The strong phenolic signal in the present extract is consistent with the polar solvent used, since solvent polarity influences the recovery of phytochemicals from testa [6,10].

The abundance of alkaloids, steroids and terpenoids is noteworthy. Sterols, terpenoids, steroids and alkaloids have been mentioned among the phytochemical groups found in testa [3], but they have been quantified far less often than phenolic compounds. These results therefore add to the limited information on these classes.

The trace level of tannins differs from the general description of testa as a source of tannins [3]. Reported profiles of testa are known to vary with geographical origin, variety, maturity, drying and solvent [3], so differences in any of these factors, or the use of methanol as the only solvent, may explain the result. Testing with additional solvents (for example aqueous or acetone-based systems) and tannin-specific quantification would be needed to clarify this.

3.3 Quantitative Phytochemical Analysis

The quantities of alkaloids, flavonoids, phenols and terpenoids at 500 and 1000 µg/mL are shown in Figure 2.

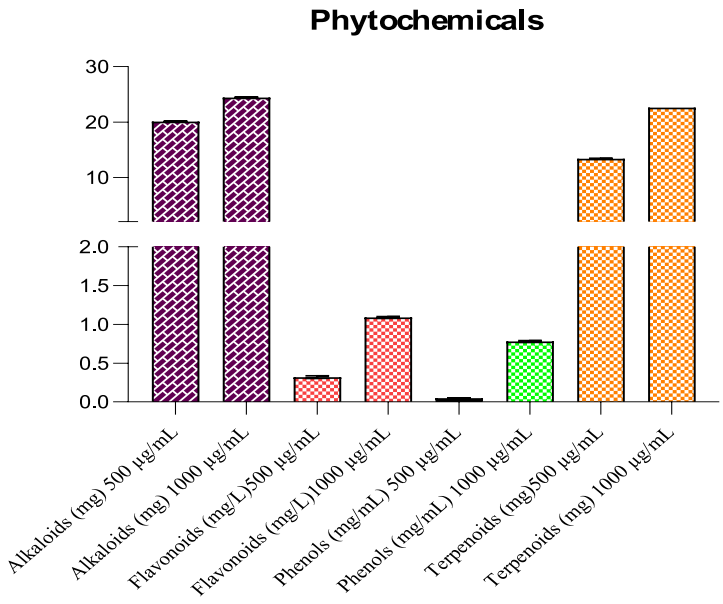


Fig. 2: Quantitative estimation of phytochemicals in coconut testa extract at two different concentrations

All four classes increased as the extract concentration was doubled from 500 to 1000 µg/mL. The increase was modest for alkaloids (about 22 %) and terpenoids (about 69 %), and much larger for flavonoids (about 3.4-fold) and phenols (about 15.6-fold). Because doubling the concentration should at most double the measured amount if the response were linear, the larger increases for phenols and flavonoids suggest a non-linear response, possibly because the low-concentration readings fall close to the lower limit of the assay. This should be checked with a full calibration and a wider concentration range.

The very small standard deviations indicate good repeatability of the measurements.

The presence of substantial amounts of phenols and flavonoids fits well with earlier work. Total phenolic content of testa extracts has been reported to depend strongly on origin, drying state and the solvent used, ranging from about 1.3 g GAE/100 g in dried testa to 6.3 g GAE/100 g in wet testa [7], and from 16.36 mg GAE/g in a methanolic extract to 44.61 mg GAE/g in a 70 % ethanolic extract [3,5]. Acidified 80 % acetone gave the highest recovery of 167 mg GAE/g of defatted testa [10]. Direct numerical comparison with these studies is not possible, because the present values were obtained at fixed extract concentrations and are expressed in different units, but the results confirm that testa is a notable phenolic source.

Phenolic compounds and flavonoids are generally regarded as safe and are valued for their ability to protect cells against free-radical damage [3]. Testa extracts have shown antioxidant activity in DPPH, FRAP and ABTS assays [5,6], and testa oil has been found to contain higher levels of phenolic constituents and tocopherols than ordinary coconut oil [3,24,25]. Testa extracts have also shown anti-hyperglycaemic effects *in vitro* and in diabetic rats [5,6,26], as well as antimicrobial and anti-inflammatory activity that depends on the solvent used [14]. Solid-state fermentation of testa has further been reported to enhance antioxidant, tyrosinase-inhibitory and elastase-inhibitory activities, pointing to cosmetic applications [27,28]. The phenolic and flavonoid contents found here are consistent with these reported bioactivities, but because bioactivity assays were not part of the present study, the link remains suggestive and should be confirmed by direct testing (for example DPPH, FRAP, α-amylase and α-glucosidase assays).

4. Conclusion

Coconut testa is rich in fat (62.23 %), with appreciable carbohydrate, crude fibre and protein, and low moisture and ash after shade-drying. Its methanolic extract contains abundant alkaloids, phenols, steroids and terpenoids, a moderate level of flavonoids, and only trace amounts of saponins and tannins, and the quantified metabolites increased with extract concentration. These findings agree with, and extend, earlier reports and highlight the potential of testa as a source of oil, fibre and bioactive compounds. Further work should include bioactivity assays, compound identification, safety assessment (anti-nutritional factors and heavy metals) and optimisation of drying and extraction conditions.

References

1. Rushdha, S. A. F., Ulpathakumbura, B. S. K., Yalegama, C., Hewapathirana, D., & Marikkar, N. (2022). Evaluation of staple foods supplemented with defatted coconut testa flour. *CORD*, 38, 43–50. https://doi.org/10.37833/cord.v38i.443
2. Marikkar, J. M. N., & Musthafa, M. M. (2022). Utilization of coconut by-products for food security and sustainability in Sri Lanka. In M. Behnassi, H. Gupta, M. B. Baig, & I. R. Noorka (Eds.), *The food security, biodiversity, and climate nexus* (pp. 251–266). Springer Nature.
3. Ulpathakumbura, S., Gunarathne, R., Marikkar, N., Feng, Y., Liu, J., & Lu, J. (2025). A review on coconut testa: Nutritional attributes, physical properties, biological activities, and product innovation. *Future Foods*, 12, 100827. https://doi.org/10.1016/j.fufo.2025.100827

4. Commey, L., Tengey, T. K., Cobos, C. J., Dampanaboina, L., Dhillon, K. K., Pandey, M. K., Sudini, H. K., Falalou, H., Varshney, R. K., Burow, M. D., & Mendu, V. (2021). Peanut seed coat acts as a physical and biochemical barrier against *Aspergillus flavus* infection. *Journal of Fungi*, 7, 1000. https://doi.org/10.3390/jof7121000
5. Adekola, K. A., Salleh, A. B., Zaidan, U. H., Azlan, A., Chiavaro, E., Paciulli, M., & Marikkar, J. M. N. (2017). Total phenolic content, anti-oxidative and anti-diabetic properties of coconut (*Cocos nucifera* L.) testa and selected bean seed coats. *Italian Journal of Food Science*, 29, 742–753. https://doi.org/10.14674/IJFS-941
6. Gunarathne, K. M. R. U., Marikkar, J. M. N., Mendis, E., Yalegama, C., Jayasinghe, U. L. B., Liyanage, R., & Jayaweera, S. (2022). Bioactivity studies of different solvent extracts of partially defatted coconut testa obtained from selected coconut cultivars. *Journal of Agricultural Sciences – Sri Lanka*, 17(1), 171–184. https://doi.org/10.4038/jas.v17i1.9618
7. Appaiah, P., Sunil, L., Prasanth Kumar, P. K., & Gopala Krishna, A. G. (2014). Composition of coconut testa, coconut kernel and its oil. *Journal of the American Oil Chemists' Society*, 91(6), 917–924. https://doi.org/10.1007/s11746-014-2447-9
8. Kumari, K. G. S. N., Ulpathakumbura, B. S. K., Gunarathna, K. M. R. U., Lai, O. M., & Marikkar, J. M. N. (2024). Creamed coconut testa and creamed coconut as substitutes for coconut milk in culinary uses. *CORD*, 40, 27–34. https://doi.org/10.37833/cord.v40i.483
9. Mahdi-Pour, B., Jothy, S. L., Latha, L. Y., Chen, Y., & Sasidharan, S. (2012). Antioxidant activity of methanol extracts of different parts of *Lantana camara*. *Asian Pacific Journal of Tropical Biomedicine*, 2(12), 960–965. https://doi.org/10.1016/S2221-1691(13)60007-6
10. Arivalagan, M., Roy, T. K., Yasmeen, A. M., Pavithra, K. C., Jwala, P. N., Shivasankara, K. S., Manikantan, M. R., Hebbar, K. B., & Kanade, S. R. (2018). Extraction of phenolic compounds with antioxidant potential from coconut (*Cocos nucifera* L.) testa and identification of phenolic acids and flavonoids using UPLC coupled with TQD-MS/MS. *LWT – Food Science and Technology*, 92, 116–126. https://doi.org/10.1016/j.lwt.2018.02.024
11. Ajaykumar, M., Patil, S. J., Doddamani, S. H., & Sadashiv, S. O. (2026). Sprouting, soaking, and drying methods alter the proximate composition of millet varieties: A comparative study. *Agriculture Archives: An International Journal*, 5(2), 35-39.
12. Giri, S., Ankali, S., Pavani, M., Binorkar, S. K., Keshamma, E., Kolgi, R. R., Lavanya, L., & Patil, S. J. (2024). Anti-inflammatory, anticancer and phytochemical potential of *Indigofera cordifolia* various extracts. *African Journal of Biological Sciences*, 6(6), 6561-6572.
13. Varsha, R., Patil, S. J., & Manjula, K. R. (2026). Pharmacological study on the neuroprotective and antioxidant potential of *Leucas aspera* (Willd.) Link methanolic extract. *Plant Science Today*, 14(2), 1-10.
14. Giri, S., Jamade, P. S., Pendakur, B., Sanjotha, G., Manawadi, S., Binorkar, S. V., Rao, N. S., & Patil, S. J. (2024). Anticancer, antidiabetic, antioxidant properties and phytoconstituents efficacy of methanolic extract of *Euphorbia milii* leaves. *African Journal of Biological Sciences*, 6(6), 5419-5429.
15. Haleshappa, R., Patil, S. J., & Murthy, S. M. (2021). Phytochemical analysis, in vitro evaluation of antioxidant and free radical scavenging activity of *Simarouba glauca* seeds. *Advances in Pharmacology and Pharmacy*, 9(1), 1-8.
16. Haleshappa, R., Patil, S. J., Usha, T., & Murthy, S. M. (2020). Phytochemicals, antioxidant profile and GC-MS analysis of ethanol extract of *Simarouba glauca* seeds. *Asian Journal of Biological and Life Sciences*, 9(3), 379-385.
17. Haleshappa, R., Sajeeda, N., Kolgi, R. R., Patil, S. J., & Murthy, S. M. K. (2022). Phytochemicals, anti-nutritional factors and proximate analysis of *Simarouba glauca* seeds. *International Advanced Research Journal in Science, Engineering and Technology*, 9(3), 218-227.
18. Manivannan, A., Bhardwaj, R., Padmanabhan, S., Suneja, P., Hebbar, K. B., & Kanade, S. R. (2018). Biochemical and nutritional characterization of coconut (*Cocos nucifera* L.) haustorium. *Food Chemistry*, 238, 153-159. https://doi.org/10.1016/j.foodchem.2016.10.127
19. Marasinghe, S. S. K., Marikkar, J. N., Yalegama, C., Wimalasiri, S., Seneviratne, G., Weerasooriya, R., & Liyanage, R. (2019). Comparison of inter-varietal differences in chemical composition and nutritional properties of coconut testa flour. *Journal of the National Science Foundation of Sri Lanka*, 47(3), 349. https://doi.org/10.4038/jnsfsr.v47i3.8699
20. Wisetkomolmat, J., Arjin, C., Satsook, A., Seel-audom, M., Ruksiriwanich, W., Prom-u-Thai, C., & Sringarm, K. (2022). Comparative analysis of nutritional components and phytochemical attributes of selected Thai rice bran. *Frontiers in Nutrition*, 9, 833730. https://doi.org/10.3389/fnut.2022.833730
21. Li, C., Stump, M., Wu, W., & Li, Y. (2023). Exploring the chemical composition, antioxidant potential, and bread quality effects of the nutritional powerhouse: Wheat bran – A mini-review. *Journal of Agriculture and Food Research*, 14, 100898. https://doi.org/10.1016/j.jafr.2023.100898
22. Ojha, S. B., Roy, S., Das, S., & Dhangadamajhi, G. (2019). Phytochemicals screening, phenolic estimation and evaluation for anti-oxidant, anti-inflammatory and antimicrobial activities of sequentially Soxhlet extracted coconut testa. *Food and Nutrition Sciences*, 10(8), 900–922. https://doi.org/10.4236/fns.2019.108065
23. Appaiah, P., Sunil, L., Gopala Krishnan, A. G., & Suresh Kumar, G. (2016). Phytochemicals and antioxidant activity of testa extracts of commercial wet and dry coconuts and cakes. *International Research Journal of Pharmacy*, 7, 9–13. https://doi.org/10.7897/2230-8407.079106
24. Zhang, Y., Zheng, Y., Duan, K., & Gui, Q. (2016). Preparation, antioxidant activity and protective effect of coconut testa oil extraction on oxidative damage to human serum albumin. *International Journal of Food Science & Technology*, 51(4), 946–953. https://doi.org/10.1111/ijfs.12945
25. Narayanankutty, A., Kunnath, K., Famurewa, A. C., Ramesh, V., Rajagopal, R., & Alfarhan, A. (2022). Variations in the composition, cytoprotective and anti-inflammatory effects of natural polyphenols of edible oils extracted from fresh and dried coconut testa. *Physiological and Molecular Plant Pathology*, 117, 101742. https://doi.org/10.1016/j.pmpp.2021.101742
26. Adekola, K. A., & Marikkar, J. M. N. (2022). Biochemical study on the anti-hyperglycemic effects of coconut testa (*Cocos nucifera* L.) and red kidney bean (*Phaseolus vulgaris*) seed coat in streptozotocin-induced diabetic rats. *Journal of Food Chemistry and Nanotechnology*, 8(1), 6–12. https://doi.org/10.17756/jfcn.2022-120
27. Jamaluddin, A., Razak, D. L. A., Rashid, N. Y. A., Sharifudin, S. A., Kahar, A. A., Saad, A. Z. M., & Long, K. (2016). Effects of solid state fermentation by *Monascus purpureus* on phenolic content and biological activities of coconut testa and rice bran. *Jurnal Teknologi*, 78(11–2), 23–28. https://doi.org/10.11113/jt.v78.9939
28. Razak, D. L. A., Jamaluddin, A., Rashid, N. Y. A., Sharifudin, S. A., & Long, K. (2016). Comparative study of antioxidant activities, cosmeceutical properties and phenolic acids composition of fermented rice bran and coconut testa. *Jurnal Teknologi*, 78(11–2), 29–34.