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RESEARCH ARTICLE

Comparison of inter-varietal differences in chemical composition and nutritional properties of coconut testa flour

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Abstract: Coconut testa is the brown colour thin outer covering of the coconut endosperm. An attempt was made to convert coconut testa into flour for bakery products. In this study, chemical composition and nutritional properties of coconut testa flour of four local cultivars, namely, San Raman, Gon Thambili, Ran Thambili and Tall × Tall were compared against those of a commercial hybrid grown in Sri Lanka. Partially defatted coconut parings of each cultivar were oven-dried and ground into coconut testa flour. Moisture, crude fat, ash and crude protein contents of coconut testa flour were determined according to AOAC methods. The carbohydrate content was calculated by the difference. Inter-varietal differences of fatty acids and micro-mineral distributions were also determined. The main constituent of coconut testa flour regardless of cultivar was carbohydrate (42.55–59.24 %) followed by protein (23.82–32.22 %) and fat (7.93–23.49 %). Commercial hybrid had the highest carbohydrate content (59.24 %) while the minimum carbohydrate content was recorded for San Raman variety (42.55 %). Highest protein content was observed in Gon Thambili (32.22 %) variety while the least was observed in commercial hybrid (23.82 %). The highest fat content was noted in San Raman variety (23.49 %). Tall × Tall variety contained the least fat content (7.93 %). Maximum ash content was observed in Ran Thambili variety (5.30 %) while the least ash content was for Gon Thambili variety (3.70 %). Highest moisture content was prevalent in San Raman variety (4.27 %) while the least was observed in commercial hybrid (2.27 %). These results suggested that coconut testa flour is a nutritious substance, which provides value addition to the under-utilised by-product of coconut processing industry.

Keywords: Coconut, coconut testa flour, fatty acids, micro-minerals, proximate composition.

INTRODUCTION

Coconut (*Cocos nucifera* L.) is a crop grown in more than 85 countries worldwide, with a total production of 54 billion nuts per annum. The island country of Sri Lanka is the world's fifth largest producer of coconuts. Coconut is grown mainly in the traditional coconut triangle, although patches of coconut cultivation could also be seen in other parts of the country. The endemic coconut germplasm of Sri Lanka consists mainly of three varieties; typica (tall palm), nana (dwarf palm), and aurantica (king coconut palm). These varieties are generally distinguishable based on their morphological characters as well as the breeding habits (Liyanage, 1958; Fernando, 1999). Despite the major characteristic differences, there are other minor variations within each variety, which lead them to be classified further into different forms of coconut known as cultivars.

As a perennial crop, coconut is one of the most economically important crops in the tropics, serving as a source of food, drink, fuel, medicine, and construction material (Lima *et al*., 2015). An average mature Sri Lankan type coconut is composed of about 45 % husk,

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13 % shell, 22 % meat and 20 % water (Marikkar *et al.*, 2009). The most economically important part of coconut is its endocarp; the hard dark core of the fruit. Inside this part is a solid white endosperm of varied thickness, depending on the maturity of the fruit (Lima *et al*., 2015). In an earlier report, Nathanael (1966) pointed out that the coconut endosperm had some unique features such that the layer closest to the water cavity was least rich in oil (~56.3%) while the layer nearest to the brown testa was richest in oil (~75.4 %). Later investigations into this aspect showed that the oil characteristics of the brown testa were slightly different from those of the oil characteristics of inner layers of the kernel (Marikkar & Nasyrah, 2012).

Coconut testa is the brown coloured thin outer covering of the coconut endosperm. It is an underutilised by-product of the desiccated coconut industry; it is often used as animal feed. Previous investigations by Appaiah *et al.* (2014) showed that it is a rich source of bioactive compounds such as phenolics and flavanoids. It has potential to be used as a functional ingredient by the food processing industry. Although, development of flour out of coconut kernel has been the interest of researchers for preparation of snack foods (Yalegama *et al*., 2013), the studies on utilisation of coconut testa as a source of flour is scanty. Hence, the aim of this study was to evaluate inter-cultivar differences in proximate composition, mineral content and fatty acid distribution of coconut testa flour of four indigenous coconut cultivars, namely, Gon Thambili (GT), Ran Thambili (RT), San Raman (SR), Tall × Tall (T×T) and commercial hybrid coconut (COM). It is believed that this information would be vital for helping to develop coconut testa flour as a raw material for nutritional improvement of the Sri Lankan society.

METHODOLOGY

Coconuts of twelve-month maturity were collected from five different local cultivars (i.e. GT, RT, SR, T×T, and COM) maintained at the varietal blocks of the Coconut Research Institute, Lunuwila, Sri Lanka during the period August 2018 to October 2018. Fifty nuts of each cultivar were sampled for seasoning followed by de-husking. Shells of the nuts were removed manually using hammers while de-pairing was done using manually operated knives. The fresh testa of individual cultivars were disintegrated separately to medium size particles using a disintegrator (Unitex Engineers, Sri Lanka). The disintegrated parings were then dried at 70 °C using a cabinet-type dehydrator (Wessberg, Martin, Germany) for 8 hrs. Two kilogram samples of dried coconut testa of each cultivar were subjected to cold press oil extraction using a micro oil expeller (Komet DD85 machine, Germany). Partially de-fatted coconut testa (less than 15% oil content) were ground into fine coconut testa flour using a grinder. The entire process was carried out according to the sequence illustrated in Figure 1. The grounded flour samples were then stored at refrigerated (4 °C) condition for further analysis. All chemicals used in this study were of analytical grade unless otherwise specified.

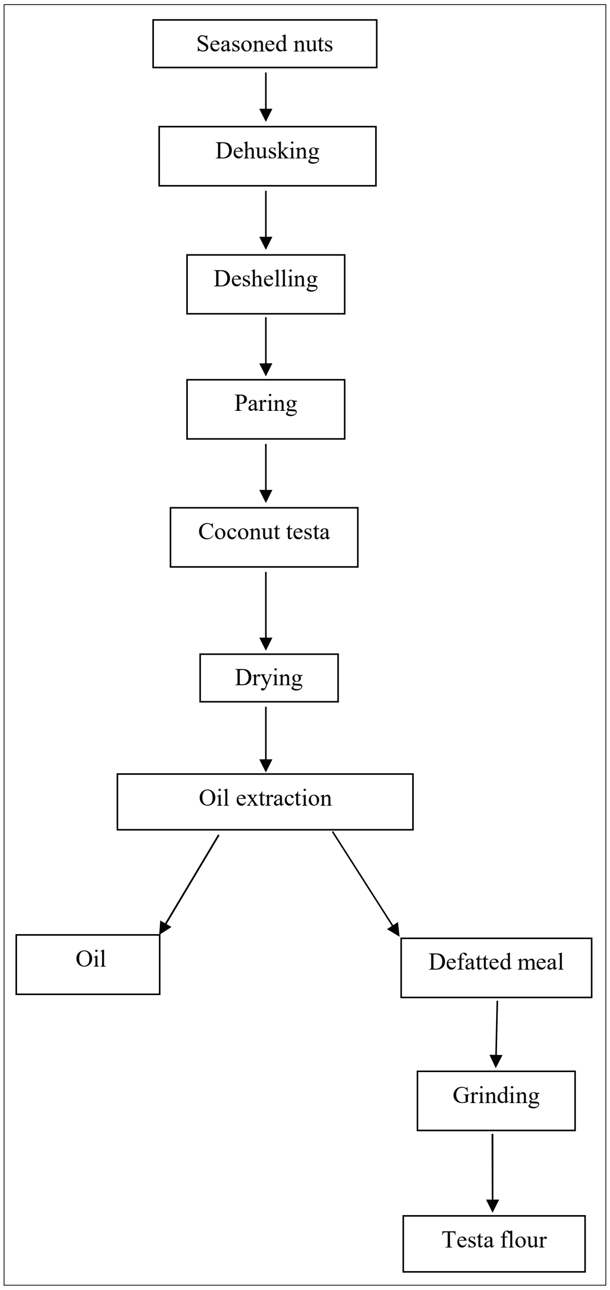

Figure 1: Process flow diagram for production of coconut testa flour

Analysis of proximate composition

Moisture, crude fat, crude protein and ash content of coconut testa flour were determined according to methods described in AOAC (2005) manual. The carbohydrate content of the flour was calculated by the difference [100- (crude protein + crude fat + ash + moisture+ crude fibre)].

Analysis of micro-minerals

Digestion of flour samples was carried out in a microwave digester (CEM MARS 6, USA) with the addition of 3 mL of 65 % nitric acid to 0.25 g of flour. The digest was filtered into a 100 mL volumetric flask and made up to mark with distilled water. This solution was used for analysis of micro-minerals using ICP spectrophotometer (Thermo scientific, iCAP 7000 series, USA).

Analysis of fatty acid profile

A sample portion of oil (0.4 g) was weighed into a screw capped glass tube and 4.0 mL portion of methanol and 0.1 mL portion of methanolic KOH were added. The mixture was heated to 60 °C in a water bath for 10 min and allowed to cool. Into this, 2 mL portion of hexane and 4 mL portion of distilled water were added. Contents were agitated at 2500 rpm for 10 min in a vortex. After allowing the contents to separate into layers, the upper layer was injected into a gas chromatograph (GC-2010 Shimadzu Corporation, Japan) fitted with a flame ionisation detector (FID). The temperature of the oven was programmed as follows: the initial temperature was 130 °C (1 min hold), then increased to 170 °C (6.5 °C min^{-1}), 170 °C to 215 °C (2.75 °C min^{-1}) and maintained at 215 °C for 12 min. Thereafter, the temperature was increased from 215 °C to 230 °C (4 °C min^{-1}) and maintained at 230 °C for 3 min. Temperatures of the injector and detector were maintained at 270 °C and 280 °C, respectively. Hydrogen was used as the carrier gas at a flow rate of 43 cm/sec. Split ratio of the injector was 50:1. Retention time of each peak was compared with that of standard fatty acid methyl esters to identify individual fatty acids. The percentage of each fatty acid was calculated by dividing the peak area of the individual fatty acid by the total of the peak areas gained for all fatty acids.

Statistical analysis

All the results from analyses were expressed as the mean value ± standard deviation. Data were statistically analysed by one-way analysis of variance (ANOVA) using Tukey's test of MINITAB (version 14) statistical package at 0.05 probability level.

RESULTS AND DISCUSSION

Moisture

Moisture is the most abundant component of most plant foods and is also a crucial factor to determine the shelf-life stability of processed products (Coultate, 2009). According to the data presented in Table 1, the mean moisture content of the testa flour of coconut cultivars was found to range from 1.8 to 4.6 %. The moisture content of SR was significantly higher than those of GT, T×T and RT. There was no significant difference among the mean moisture contents of GT, T×T and RT. However, the mean moisture content of COM was significantly lower than those of GT, T×T and RT ($p < 0.003$). When compared with previous reports, the moisture contents of coconut testa flour used in this study were lower than those of commercial wheat flour (Nasir *et al*., 2003). Organisms naturally present in the flour start to grow at high moistures, producing off odours and flavours. Hence, Nasir *et al.* (2003) suggested that wheat flour having less than 10% moisture would be appropriate for extended shelf life. Further, more mold growth and insect infestation has been noticed in wheat flour having higher moisture during storage.

Protein

Proteins are the third most abundant class of macromolecules in food systems; they perform numerous biological functions in living systems (Chang, 1998). According to the data presented in Table 1, the mean protein content of the testa flour of coconut cultivars was found to range from 23.8 to 32.2 %. The lowest protein content was found with COM while the highest was recorded for GT. However, there was no significant difference between the protein contents of RT and SR cultivars. The mean protein content of T×T was significantly higher than those of RT, SR and COM. Previous researchers have examined the protein content of defatted coconut flour obtained from the whole endosperm, but not the protein content of the testa. In an early report, Ediriweera and Kashizumi (1991) pointed out that the whole endosperm of fresh coconut has about 4 % protein and the value might increase in defatted meals after extraction of milk. In a study on mixed coconut types, Yalegama and Chavan (2006) found that coconut flour obtained after oil extraction of the whole kernel has around 18 to 20 % of protein. According to another report, Beansch *et al.* (2004) reported that defatted coconut flour obtained after the extraction of virgin coconut oil contained about 20 % protein; the value was higher than those reported for commercially milled wheat flour, which contained about 10.33 % protein. The protein content is an important parameter for bread making as flour containing higher protein contents would be more expensive than flours of lower protein content. Another important feature of coconut testa flour is that its protein is gluten-free, which is advantageous for people with celiac disease or gluten intolerance.

Table 1: Inter-varietal differences in proximate composition of coconut testa flour of different coconut cultivars

Parameter	Cultivar				
	SR	GT	RT	T×T	COM
Moisture (%)	4.27 ± 0.31^{c}	3.40 ± 0.53^{b}	3.07 ± 0.11^{b}	2.80 ± 0.40b	2.27 ± 0.42a
Ash (%)	5.00 ± 0.57^{c,d}	3.70 ± 0.14^{a}	5.30 ± 0.14^{d}	4.20 ± 0.00b	4.50 ± 0.14c
Crude protein (%)	24.69 ± 0.74^{a}	32.22 ± 2.48^{c}	25.39 ± 0.25a	28.37 ± 0.00b	23.82 ± 0.99a
Crude fat (%)	23.49 ± 4.91^{d}	13.41 ± 4.56c	13.28 ± 0.06c	7.93 ± 2.22a	10.17 ± 1.84b
Total carbohydrates (by difference) (%)	42.55	47.27	52.96	56.7	59.24

Each value in the table represents the mean of three replicates. Means within each row bearing different superscripts are significantly ($p < 0.05$) different.

SR - San Raman; GT - Gon Thambili; RT - Ran Thambili; T×T - Tall×Tall; COM - commercial hybrid

Fat

Dietary fat or lipid is one of the most important macronutrients that provides energy and essential fatty acids to various functions of the human body (Raihana *et al.*, 2015). Fat contents of food usually vary from very low to high depending on the source of origin, variety, geographical location, etc. (De Man, 1999). The data presented in Table 1 compared the inter-varietal differences of fat content among the locally available coconut cultivars. The mean fat content of the testa flour of coconut cultivars was found to vary from 7.93 to 23.49 %. According to literature, previous researchers have examined the fat content of coconut flour obtained from the whole endosperm, but not the fat content of the testa, to compare the inter-varietal differences of local cultivars. For instance, Yalegama and Chavan (2006) reported that coconut flour obtained after oil extraction of the whole kernel had about 10 to 13 % fat. In a separate communication, Beansch *et al*. (2004) stated that defatted coconut flour obtained after the extraction of virgin coconut oil contained about 12.0 % fat (w/w, dry basis). According to Najwa *et al.* (2017), the fat content of defatted coconut residue left after extraction of coconut milk was found to be 17.26 %. All these indicated that the method of preparation or the nature of sampling in different studies could have contributed to the observed variation in fat content of different coconut testa flour samples.

Fatty acid distribution

The fatty acid distributions of oils extracted from testa flour of different cultivars were compared as shown in Table 2. The oil samples consisted of 88.75–91.23 % saturated fatty acids (SFA) and 8.76–11.19 % unsaturated fatty acid (USFA). Among the different cultivars, lauric acid was the dominant fatty acid (42.65–45.97 %), followed by myristic acid (19.69–21.46 %) and palmitic acid (9.42–10.24 %). In a previous study reporting the composition of coconut testa oil, lauric acid (42.28 %) was found to be the predominant fatty acid, followed by myristic acid (18.99 %) and palmitic (11.57 %) acid (Zhang *et al.*, 2015). In another study to compare the composition of coconut testa oil and ordinary coconut oil, Marikkar and Nasyrah (2012) observed the proportion of fatty acids in the order of lauric > myristic > palmitic acids. However, some differences were observed in the proportional distribution of fatty acids in the oils of copra testa and wet-coconut testa; they took the order of lauric > myristic > oleic acids (Appaiah *et al*., 2014). With reference to the report of Appaiah *et al.* (2014), the mean proportion of lauric acid observed in the present study (44.92 %) was slightly higher than those of copra testa (40.9 %) and wet-coconut testa (32.4 %). When compared to oils from coconut testa flour of the present study (7.02 %), copra testa (12.2 %) and wet-coconut testa (17.8 5%) had considerably higher oleic acid contents. However, the mean percentage of myristic

Table 2: Inter-varietal differences in fatty acid compositions of coconut testa flour of different coconut cultivars

Fatty acid	Cultivar				
	SR	RT	GT	T×T	COM
C8:0	7.62 ± 0.01^{b}	8.05 ± 0.08^{c}	7.60 ± 0.01^{b}	8.14 ± 0.03^{c}	7.33 ± 0.01^{a}
C10:0	4.96 ± 0.01^{c}	5.32 ± 0.03^{d}	4.72 ± 0.11^{b}	5.21 ± 0.04^{d}	4.45 ± 0.03^{a}
C12:0	$45.48 \pm 0.03^{b,c}$	45.97 ± 0.23^{c}	45.23 ± 0.1^{b}	45.29 ± 0.11^{b}	42.65 ± 0.21^{a}
C14:0	20.25 ± 0^{b}	19.69 ± 0.06^{a}	21.46 ± 0.03^{c}	20.2 ± 0.04^{b}	21.15 ± 0.21^{c}
C16:0	9.84 ± 0.03^{b}	9.42 ± 0.11^{a}	9.55 ± 0.06^{a}	9.43 ± 0.04^{a}	10.24 ± 0.04^{c}
C18:0	2.23 ± 0.69^{a}	2.55 ± 0.35^{a}	2.66 ± 0.09^{a}	2.52 ± 0.11^{a}	2.92 ± 0.02^{a}
C18:1	$7.22 \pm 0.65^{a,b}$	6.63 ± 0.20^{a}	6.27 ± 0.05^{a}	$7.09 \pm 0.05^{a,b}$	7.91 ± 0.01^{b}
C18:2	2.38 ± 0^{b}	2.34 ± 0.04^{b}	2.49 ± 0.07^{b}	2.09 ± 0.04^{a}	3.28 ± 0.02^{c}
SFA	90.39 ± 0.66^{b}	91.01 ± 0.16^{b}	91.23 ± 0.02^{b}	90.80 ± 0.08^{b}	88.75 ± 0.06^{a}
USFA	9.6 ± 0.65^{a}	8.98 ± 0.17^{a}	8.76 ± 0.02^{a}	9.19 ± 0.08^{a}	11.19 ± 0.01^{b}

Each value in the table represents the mean of three replicates. Means within each row bearing different superscripts are significantly ($p < 0.05$) different.

SR - San Raman; GT - Gon Thambili; RT - Ran Thambili; T×T - Tall×Tall; COM - commercial hybrid

C:8 - caprylic; C:10 - caproic; C12:0 - lauric, C14:0 - myristic, C16:0 - palmitic, C18:0 - stearic; C18:1 - oleic; C18:2 - linoleic; SFA - saturated fatty acid; USFA - unsaturated fatty acid

acid (20.55 %) in the present study was comparatively similar to those of copra testa (20.9 %) and wet-coconut testa (20.2 %).

The inter-varietal differences of the distribution of individual fatty acids among cultivars RT, GT, SR, T×T and COM are of considerable interest in nutrition. Generally, in this study there is no particular pattern of change among the distribution of various fatty acids. Significant differences were noticed among the cultivars with regard to the distribution of fatty acids such as caprylic acid and caproic acid, although the differences were minute. The proportion of lauric acid was highest for RT while the same for COM was lowest. Likewise, the proportion of myristic acid was highest for GT while the same for RT was lowest. Among all five cultivars, the proportions of stearic acid and unsaturated fatty acids such as oleic and linoleic acids were low. As a result, coconut testa flour of these cultivars might display better shelf-life stability than wheat flour. It is because coconut testa flour with less amounts of unsaturated fatty acids than wheat flour would become less prone to auto-oxidation. In a previous study, Nikolic *et al*. (2015) reported that the predominant fatty acid of wheat flour was linoleic acid (66.57 %), followed by palmitic acid (15.36 %) and oleic acid (13.34 %). According to another report by Nikolic *et al*. (2008), the major fatty acid of wheat flour was found to be linoleic acid (57.67 %), followed by oleic acid (20.28 %) and palmitic acid (19.56 %).

Ash

Ash is the composite material of minerals present in flour. Determination of the ash and mineral content of foods is important for a number of reasons. For instance, the quality of many foods depends on the concentration and type of minerals they contain, including the taste, appearance, texture and stability. Previous studies have shown that ash content of wheat flour varies from about 1.50 to 2.00 % (NDSU, 2018). It is generally accepted that the ash content of flour does not affect the baking performance in majority of the cases (Borla *et al*., 2004). The data presented in Table 1 shows that ash contents of the samples ranged from 3.6 to 5.4 %. Mean ash content of GT was significantly ($p < 0.012$) lower than those of SR, RT, T×T and COM. However, no significant ($p > 0.05$) differences were noticed among mean ash contents of SR, RT, T×T and COM. In a previous study, Yalegama *et al*. (2013) observed the changing pattern of ash content among coconut flour/ or residue samples obtained from different methods of processing. For instance, the ash contents of coconut residue samples obtained after milk extraction by two different machines were found to be 1.5 % (Yalegama *et al*., 2013) and 0.54 % (Najwa *et al*., 2017). These differences could be due to the difference in extraction efficiencies of the two milk extractor machines used by these two groups. However, higher ash content values were noticed for coconut flour obtained through virgin coconut oil extraction. This could probably be because more minerals are washed away during the aqueous exaction of coconut milk, while they are retained with the defatted residue coming from coconut oil extraction.

Micro-mineral distribution

Comparing micro-mineral distribution in food stuffs is generally important for the assessment of nutritional values. Although they are required in minute quantities, micro minerals are essential to catalyse enzymatic biochemical reactions of various metabolisms. The data presented in Table 3 compares the distribution of micro-minerals present in the coconut testa flour of the cultivars. Mn was the most prevalent mineral (73.71–94.1 mg/kg), followed by Zn (29.65–57.34 mg/kg) and Cu (29.94–45.14 mg/kg). According to previous studies, whole coconut kernel was known to possess minerals such as Fe, Cu, Mn and Zn (Yalegama *et al*., 2013). Mn is an essential micro-mineral that acts as a cofactor to many enzymes involved in bone formation and various other metabolic processes. It is said to be present in trace amounts in a variety of food items such as nuts, whole grains, and some vegetables.

In this study, Mn content of the samples ranged from 73.71 to 94.1 mg/kg; there was no statistically significant difference among the mean Mn content of RT, GT and COM. However, the mean Mn content of SR was significantly ($p < 0.001$) higher than those of RT, GT and COM. Meanwhile the mean Mn content of T×T was significantly ($p < 0.001$) lower than those of RT, GT and COM. Zn was the next most abundant micro-mineral detected in coconut testa flour of the local coconut cultivars. According to scientific studies, Zn is the cofactor for many enzymes affecting growth and digestion; its deficiency can lead to growth retardation, sexual immaturity and impaired immune response (Coultate, 2009). Generally, protein containing foods are a good source of zinc. In this study, Zn contents of the samples ranged from 29.65–57.34 mg/kg. There was no statistically significant ($p > 0.065$) difference in the mean Zn contents among SR, RT, GT, T×T and COM. The next important micro-mineral is Cu, which plays an important role in several enzymatic reactions (Coultate, 2009). It is a constituent of enzymes such as tyrosinase, cytochrome oxidase, ascorbic acid oxidase, uricase, monoamine oxidase, etc. Legumes, whole grains, nuts, shellfish, and seeds are some other sources that provide Cu in human nutrition. Since Cu is a transition metal, citrus fruit juices might help Cu absorption through metal chelating effect. According to Table 3, Cu contents of coconut testa flour of cultivars were found to range from 29.94–45.14 mg/kg. The mean Cu content was highest for RT while the mean Cu content decreased in order of RT, SR and GT in a statistically significant ($p < 0.001$) manner. However, there was no significant difference between the mean Cu content of T×T and COM. The data presented in Table 3 shows that Fe contents of the samples were in the range of 0.48–2.6 mg/kg. Fe is an essential mineral for hemoglobin and myoglobin, which are part of the oxygen transport system of the human body. Iron balance is also critical for brain function; the deficiency might lead to tiredness, fatigue and anemia (Coultate, 2009). Red meats, fish, poultry, eggs, and legumes are

Table 3: Inter-varietal differences in mineral composition of coconut testa flour of different cultivars

Mineral element	Cultivar				
	SR	RT	GT	T×T	COM
Ni (mg/kg)	6.54 ± 0.67^{c}	6.69 ± 1.5^{c}	3.17 ± 78.4^{b}	2.12 ± 0.10^{a}	3.89 ± 0.04^{b}
Zn (mg/kg)	46.7 ± 6.50^{b}	54.5 ± 4.00^{c}	44.5 ± 8.50^{b}	33.4 ± 5.30^{a}	36.2 ± 0.70^{a}
Mn (mg/kg)	93.82 ± 0.38^{d}	89.20 ± 0.41^{c}	85.62 ± 3.02^{b}	75.30 ± 2.25^{a}	83.60 ± 1.43^{b}
Cr (mg/kg)	6.78 ± 0.65	7.56 ± 0.32	1.97 ± 0.02	0.68 ± 0.02	0.35 ± 0.02^{a}
Co (mg/kg)	0.15 ± 0.57	0.21 ± 0.03	0.11 ± 0.00	0.07 ± 0.01^{a}	0.16 ± 0.00
Cu (mg/kg)	38.7 ± 0.70	44.7 ± 0.70	34.8 ± 0.90	30.5 ± 0.80^{a}	31.0 ± 0.70^{a}
Fe (mg/kg)	2.60 ± 0.16^{c}	1.38 ± 0.41^{b}	0.91 ± 0.64^{a}	0.48 ± 0.26^{a}	0.61 ± 0.00^{a}
Ba (mg/kg)	1.1 ± 0.02^{c}	1.19 ± 0.11^{c}	0.52 ± 0.09^{b}	0.36 ± 0.10^{a}	0.51 ± 0.03^{b}
Mo (mg/kg)	0.26 ± 0.01^{b}	0.31 ± 0.08^{b}	0.12 ± 0.00^{a}	0.12 ± 0.01^{a}	0.09 ± 0.03^{a}

Each value in the table represents the mean of three replicates. Means within each row bearing different superscripts are significantly ($p < 0.05$) different.

SR - San Raman; GT - Gon Thambili; RT - Ran Thambili; T×T - Tall×Tall; COM - commercial hybrid usually good sources of Fe. The mean Fe contents of RT (1.38 ± 0.41 mg/kg), GT (0.91 ± 0.64 mg/kg), T×T (0.48 ± 0.26 mg/kg) and COM (0.61 ± 0.00 mg/kg) were more or less equal, but significantly lower ($p < 0.05$) than that of SR (2.60 ± 0.16 mg/kg).

Total carbohydrate content

Total carbohydrates consist of multiple nutrients, which include dietary fibre, sugars and starches. The data presented in Table 1 compares the total carbohydrate contents of coconut testa flour obtained from five local coconut cultivars. The total carbohydrate contents of the samples were found to range from 59.24–42.55 %; the mean total carbohydrate content was lowest for SR variety, while the highest value of the same was recorded for COM. The inter-varietal differences of total carbohydrates among the cultivars were significantly ($p < 0.05$) different. The carbohydrate content of coconut testa flour is generally lower than that of traditional grain flours such as wheat flour. Kassegn (2018) reported that 100 g of wheat flour might contain around 64–72 g of carbohydrates while David *et al*. (2015) found that the total carbohydrate content of soft wheat flour was around 83 %. According to previous reports of Yalegama and Chavan (2006), the total carbohydrate content of coconut flour was around 50 %. In a separate study, Beansch *et al*. (2004) also reported that the total carbohydrate content of defatted coconut flour obtained after the extraction of virgin coconut oil was about 52.0 % (w/w, dry basis). The occurrence of higher proportions of fat and protein in coconut flour would be a reason for the lower proportion of total carbohydrates. In addition, the quality of carbohydrate is also dependent on its fibre content and glycemic index. As it contains enough fibrous matter, it can also be useful as a thickening agent in sauces or soups. In a previous study, Leelavathi and Rao (1993) reported that wheat flour contained a low amount of total dietary fibre and therefore, supplementation of wheat flour with defatted coconut flour could increase the dietary fibre content of food formulations.

CONCLUSIONS

In this study, inter-varietal differences of chemical composition and nutritional properties of coconut testa flour of different indigenous cultivars were compared. In general, coconut testa flour of all cultivars displayed higher contents of protein and fat than wheat flour; hence partial substitution of wheat flour with coconut testa flour would improve the nutritional quality of flour-based products. Among the different cultivars, the highest protein content was observed in GT while the lowest protein value was observed for COM variety. The highest fat content was noted in SR while least fat content was found in T×T. The maximum ash content was found in RT while the lowest ash content was in GT variety. COM hybrid had the highest carbohydrate content while the lowest carbohydrate content was recorded for SR variety. In general, coconut testa flour of all cultivars contained micro-minerals such as Mn, Cu and Zn. There were noticeable cultivar differences with regard to mineral composition. Highest amounts of Fe and Mn were present in SR while the highest content of Cu and Zn were found with RT. All these findings suggest that coconut testa flour can become a potential source for value addition purposes and reduce the wastage of under-utilised coconut testa generated by the coconut processing sector.

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