

Deviation of Chemical Properties of Kithul (*Caryota urens*) Flour Obtained from Five Different Growing Areas in Sri Lanka.

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Abstract- Kithul (*Caryota urens*) flour is a good ingredient for food applications having considerable gelling property. The objectives of this study were to analyze the proximate composition of Kithul flour and study differences among flour samples from five main Kithul growing areas in Sri Lanka. Kithul flour (*Caryota urens*) samples were collected from both household and commercial markets representing five main Kithul growing districts in Sri Lanka namely Rathnapura, Kegalle, Kandy, Matale and Kurunegala district. According to the results of proximate analysis, there were significant differences ($p < 0.05$) among flour samples obtained from the selected districts in Sri Lanka with respect to moisture content, ash, total fat, protein and crude fiber. As per the results moisture content ranged from 8.58% to 11.41% while protein content ranged from 0.92 to 1.09 g/100g (dry basis). Mean value of the total fat content was 0.36 ± 0.09 g/100g (dry basis) and Crude fiber content and ash content were ranged from 0.85 to 1.34 g/100g (dry basis) and 0.24% to 1.12%, respectively. However, no significant differences ($P > 0.05$) were presented among samples for analyzed three minerals (Na, Fe, and Zn). Calcium content of the Kithul flour was significantly lower ($p < 0.05$) in samples from Kandy (38.95 ± 12.07 mg/100g) compared to those from all other districts, while Potassium content was lower ($p < 0.05$) in flour from Kandy (28.22 ± 3.57 mg/100g) compared to samples from other four districts. Analyzed results revealed that there were significant differences among Kithul flour samples obtained from five main growing districts with respect to chemical composition except Sodium, Iron and Zinc content, which could be a considerable point for using composite Kithul flour

from different growing areas for future food applications.

Index Terms- Kithul flour, *Caryota urens*, chemical composition, Kithul growing area, mineral content, proximate analysis

I. INTRODUCTION

Kithul (*Caryota urens*) is native to India, Sri Lanka and Malaysia (Rajyalakshmi 2004, 144-149) with different names as sopari (Bengali); toddy palm, fishtail palm, Indian sago palm, wine palm, jaggery palm, kitul palm (English); mari (Hindi); mada, dirgha (Sanskrit); kitul (Sinhala); and kundal panai, koondalpanai, thippali, tippili, konda panna (Tamil) (Orwa 2009, 1-5). The genus *Caryota* has 27 species found among tropical Asian countries (especially in Malay Archipelago, Australia, and New Guinea) as different types of palms. The scientific name *Caryota* forms by the Greek word of *karyotes*, ("nutlike"). This word mentions about the small, hard fruits of the palms. *Urens* means "burning," and describes the outer shell of the Kithul fruits (Yvonne 1995, 161-176). According to literature in Sri Lanka Kithul palms are common in the mid and low country interior up to 1,500 m (Yvonne 1995, 161-176), while its biophysical limit is altitude up to 1200 m (Orwa 2009, 1-5). In the lowlands, the palms occur predominantly in the natural forests (Yvonne 1995, 161-176).

The starch stored in trunk of the Kithul tree is the main edible food product of this palm. According to the reported values, palm generates

24 tons/hectare per year compared to rice which produce 6 tons / hectare per year while 5.5 tons/ hectare from corn and 2.5 tons/ hectare from potato (Shoon, 2000). The trunk produces around 100 -150 kg per palm of the pith from which flour is made. It is reported that the flour from Kithul (*Caryota urens*) is to be equal in quality to the best industrial sago which is obtained from *Metroxylonmsagu Rottb*, while it is valued for cooling properties (Council of scientific 1992, 321-324). Flour is the stored product of carbohydrates in the food reserves located in the pith of the trunk. The starch is concentrated towards the top of the trunk. Starch is converted to sap and transported via phloem tubes when tapping. Therefore, tapping trees are deficient in flour. Once the production of sap is complete, sugar can be converted to starch and re-stored in the pith. The pith of starch rich trees is soft and tasty. Most suitable months for the extraction of starch are January, February and March (Seneviratne 2011, 217-222).

According to reported data, palms belong to one of the oldest families of the plants on earth (Ishizuka 1995, 75-76) and it is a good source of

food. So it is necessary to focus on Kithul like palms as food resources. As per the Indian food industry, lots of attention is currently being focused on the plant resources existing in the wild as uncommon food resources (Rajyalakshmi 2004,144-149) which could be used for new product development.

According to the national survey conducted in 2009, the total number of Kithul trees found in the island amounts to 2,977,261 [vastly spread in Sabaragamuwa, Central and Uva provinces (Table.1)]. (Though matured or 'peedunu' trees was being 574,259, which sap was extracted amounts to only 89,855 (15.64%). Further evaluation proves that among the opportunities to develop Kithul industry there are 84% of the matured trees to be tapped (Ministry of traditional industries 2009,3-7). This is the main point to deviate another expansion of Kithul industry as Kithul flour because non-tapping trees are more suitable for collecting starch (Seneviratne 2011, 217- 222). [And 2,403,002 of new trees are available for maturation in 2014 (Ministry of traditional industries 2009, 3-7)].

Table.1 Statics on Kithul palms by Province

Province	Young Trees (below 5 years)	Middle age Trees	Matured Trees	Total Trees	Number of Trees tapped at present (2009)
Sabaragamuwa*	372,331	246,924	133,743	752,998	21,667
Central*	336,687	195,991	126,168	658,846	25,930
Uva	348,622	183,923	104,035	636,580	13,067
Southern	187,004	134,765	117,399	439,168	19,918
Western	145,783	88,454	59,462	293,699	7,634
North Western*	80,186	42,054	26,834	149,074	1,563
Eastern	14,615	9,257	3,294	27,166	20
North Central	10,888	5,518	3,324	19,730	56
Sri Lanka	1,496,116	906,886	574,259	2,977,261	89,855

Data extracted Source: Statistic on Kithul palms in Sri Lanka, 2009 (Ministry of traditional industries 2009,3-7)

*provinces that were selected for this study.

Kithul (*Caryota urens*) associate with large number of commercial products in Sri Lanka (Punchihewa 2012) such as Kithul sap for treacle, toddy and jaggery while Kithul flour is used for pudding (*thalapa*), porridge (*Kenda*), rice cake (*kawum*), a sweet meat (*Dodol*) and

dough of flour heated in a pan (*Rotee*) etc. (Seneviratne 2011,217-222). An Indian study carried out for product development (biscuit, noodle and gel) by purified Kithul flour has succeed and the author concludes *Caryota palm* flour can be used as a prospective raw material

for development of various processed product according to the industrial requirements (Rajyalakshmi 2004,144-149).The objectives of this study were to analyze the proximate composition of Kithul flour and study differences among flour samples from five main Kithul growing areas to find out the most suitable growing area for Kithul flour production in future food applications.

II. RESEARCH METHODOLOGY AND MATERIAL USED

2.1 Selection of Area: Five agency blocks, namely Kurunegala (KU) (North-western province), Matale(MA) and Kandy(KA) (Central province), and Kegalle(KE) and Rathnapura(RA) (Sabaragamuwa province), were selected for the study as the five main growing area in Sri Lanka.

2.2 Procurement of samples: Six Kithul flour samples (500g) were collected from each district from both household and commercial markets

2.3 Sample preparation and Storage: Samples were sifted through a 355 μm sieve and packed in air-tight containers, then stored in refrigerator (5 °C) until further analysis.

2.4 Proximate analysis: Moisture, total fat, protein (N x 6.25), ash and crude fiber content were determined according to AOAC (1990) methods. Carbohydrate contents were determined by difference sum of above categories. Mineral content was determined by dry ashing method (AOAC 1990). The ash was dissolved in conc. HCl, filtered and dilute with distilled water. Prepared samples were analyzed with a standard series of solutions by Atomic Absorption Spectrophotometer (Thermo Scientific ICE3000 series).

2.5 Statistical Analysis: Results were analyzed using one-way analysis of variance (ANOVA) at 0.05 probability level with MINITAB software package (version 17 for Windows). Cluster analysis has done for grouping of clusters which has contributed common characteristics. Pearson correlation has used to identify the linear relationship between two continual variables.

III. RESULTS AND DISCUSSION

3.1 Area Selection: Areas were selected based on the statistics on Kithul palms by district (Table.2, Statistics on Kithul palm in Sri Lanka, 2009; Ministry of traditional industries 2009, 3-7). Five different districts representing three different provinces of two different climate zones (wet zone and intermediate zone) were chosen which has total number of palms above 100,000. According to the statistical study the highest density of the Kithul palms were present in the wet and intermediate zones. However, ecologically Kithul is found in monsoon climates and peri-humid regions. It prefers moist, shady, cool places (Orwa 2009, 1-5).

3.2 Chemical Composition

According to the results of proximate analysis, there were significant differences ($p > 0.05$) observed among flour samples obtained from the five selected districts from the three main Kithul growing provinces in Sri Lanka (Table 2). Moisture content of the flour samples indicated significant differences ($p < 0.05$). This is totally dependent on drying method which was used in flour preparation and storing and climatic conditions. Under high moisture content flour form big flour clusters, which are not suitable for fine texture during the cooking (Seneviratne 2011, 217-222). Moisture content is an important parameter to determine shelf life of the flour. According to the literature, moisture levels greater than 12% promote microbial growth, which leads to short shelf life (Padonou 2010,1402-1410 & Harris 2011,20-24). Although moisture content of studied flour samples were ranged 8.5% to 11.4% (Below the 12%).

Protein contents in studied flour samples were significantly different ($p < 0.05$) as table2. The mean protein content was 1.00 ± 0.17 , while it ranged from 0.92 to 1.09 g/100g (dry basis). Literature show that protein content of purified Kithul flour is 1.13 g/100g (Tanuja et al 2004,80-82) which is comparable with these results.

Total fat content of flour from five different districts also was significantly different ($p < 0.05$)

as flour samples from Rathnapura (0.43 g/100g) showed higher value than other districts. But flour samples from Kandy indicated slightly lower fat content (0.29 g/100g) while mean value was 0.36 ± 0.09 g/100g (dry basis). Comparably total fat content of Kithul flour is slightly lower than cassava starch (0.74 -1.49 g/100g) (Emmanuel 2012, 175-181) as well as Sweet potatoes (1.1-1.7g/100g) (Senanayake et al 2013,87-96).

Same trend was observed for crude fiber content, with significant differences ($p < 0.05$) as highest value reported from Kurunegala district (1.34 g/100g). Among five district samples fiber content showed a mean value of 1.06 ± 0.54 g/100g (dry basis) and ranged from 0.85 to 1.34 g/100g (dry basis). According to literature, the crude fiber content of Kithul flour has been reported as 0.2 to 3.5% (Rajyalakshmi et al 1994,53-61). The fibre content can be different due to flour extraction method. As per the literature in dry method removed portions of pith were dried, pounded and sieved through the household strainer(Seneviratne 2011, 217-222), so it contains higher fibre content than wet method where pieces of pith were removed and

pounded, mixed with water and sieved from a piece of cloth. The starch granules passed through the cloth were allowed to settle. The water was drained and the remaining starch was dried. Dry method was being practiced in Hambanthota district whereas the wet method is used in the other areas of the island (Seneviratne 2011,217-222). Crude fiber content showed comparable values with cassava root starch (1.4 to 3.2 g/100g) (Emmanuel 2012,175-181) . Depending on the extraction procedure ash content also can vary, by addition of sand particles could present by passing through the strainer or cloth.

As per the results of this study total ash content of the flour samples were significantly different ($p < 0.05$) in flour obtained from five different districts with the range of 0.24% to 1.12% while literature shows 0.65 % (Jayakody 2009,4-27) and 1.5-2.5 % (Rajyalakshmi et al 1994,53-61).Carbohydrate content was calculated by difference of sum of above five components. Because of the moisture content of flour directly affect on this calculation there was slight variations of the carbohydrate content.

Table 2: Variations on Chemical composition of Kithul flour collected from five different Districts in Sri Lanka

Sampling Area	Ash Content (g/100g db)*	Total Fat (g/100g db)*	Crude Fibre (g/100g db)*	Crude Protein (g/100g db)*	Moisture Content (g/100g db)*	Carbohydrate(By Difference)*
KA	0.24 ± 0.15^c	0.29 ± 0.01^b	0.85 ± 0.49^b	1.00 ± 0.22^{ab}	8.80 ± 2.75^b	88.81 ± 2.91^a
KE	1.12 ± 0.67^a	0.34 ± 0.03^b	1.15 ± 0.39^{ab}	1.04 ± 0.12^{ab}	8.61 ± 0.72^b	87.55 ± 1.26^a
KU	0.92 ± 0.34^{ab}	0.36 ± 0.06^b	1.34 ± 0.37^a	1.09 ± 0.16^a	8.94 ± 3.13^b	87.19 ± 2.64^{ab}
MA	0.67 ± 0.16^b	0.37 ± 0.08^b	1.11 ± 0.68^{ab}	0.92 ± 0.17^b	11.41 ± 1.17^a	85.52 ± 1.67^{ab}
RA	0.91 ± 0.37^{ab}	0.43 ± 0.15^a	0.87 ± 0.58^{ab}	0.93 ± 0.13^b	8.58 ± 1.12^b	88.21 ± 1.33^a
Mean Value	0.77 ± 0.42	0.36 ± 0.09	1.06 ± 0.54	1.00 ± 0.17	9.27 ± 2.26	87.46 ± 2.32

Same superscription in each column is not significantly different. db- represents meaning of dry basis.

*Each value represents the means of three estimations of three samples from each district.

Cluster analysis results are plotted in Figure1. Mean values of proximate composition in Kithul flour samples from five different growing areas fall into two main clusters and one sub cluster as per the similarity (Figure.1). Kithul flour from Kurunegala (KU) and Kegalle (KE) presented strong similarity level (67.21), while Kandy (KA) and Rathnapura (RA) were having next similarity level(17.04). Kithul flour from Matale (MA) district was presented a different cluster with Kurunegala (KU) and Kegalle (KE) sub cluster with the least similarity level (15.22) among other 4 districts.

Moisture content and carbohydrate value presented strong, negative correlation ($r = -0.922$, $p < 0.05$) though which is significant. This could be linked with carbohydrate calculation method. Because moisture content was directly affected on carbohydrate value when determined using difference calculation method this correlation was reasonable. Another correlation was presented by protein and fiber content as moderate, positive, significant relationship ($r = 0.635$, $p < 0.05$) . which indicates that, as protein increase, fiber also increases. by following in same pattern by both variables. There was no any noticeable correlation among these flour treatments with regard to mean values of proximate and mineral composition.

Table 3: Mineral content of Kithul flour collected from five different Districts in Sri Lanka

Sampling Area	Calcium (mg/100g db)*	Potassium (mg/100g db)*	Sodium (mg/100g db)*	Iron (mg/100g db)*	Zinc (mg/100g db)*	Magnesium (mg/100g db)*
KA	38.95±12.07 ^b	28.22±3.57 ^b	42.57±20.29 ^a	12.92±4.25 ^a	3.34±2.49 ^a	41.81±13.92 ^c
KE	76.44±23.29 ^a	68.73±18.38 ^a	35.56±16.95 ^a	11.96±3.61 ^a	3.90±3.02 ^a	82.12±31.94 ^a
KU	75.13±28.57 ^a	55.66±21.19 ^a	57.17±36.90 ^a	13.51±3.33 ^a	3.43±2.40 ^a	58.10±25.62 ^{bc}
MA	80.95±27.38 ^a	54.27±18.11 ^a	52.20±23.74 ^a	11.65±3.14 ^a	4.24±2.75 ^a	59.23±9.66 ^{bc}
RA	71.85±21.75 ^a	55.68±14.31 ^a	62.78±41.78 ^a	14.13±3.83 ^a	2.47±1.84 ^a	78.38±27.17 ^{ab}
Mean Value	68.66±27.44	52.51±20.78	50.06±30.53	12.83±3.69	3.47±2.54	63.93±27.12

Values with same superscriptions in each column are not significantly different.

*Each value represents the means of three estimations of three samples from each district.

Dendrogram of Proximate Composition
Complete Linkage, Pearson Distance

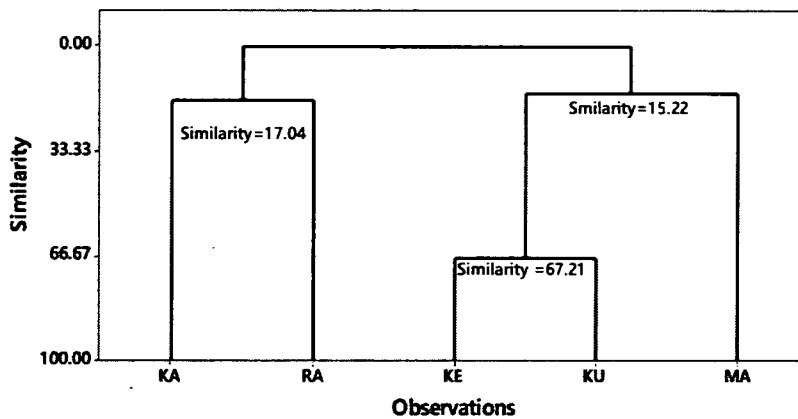


Figure 1. Clusture Analysis for Proximate analysis of Kithul flour from five different growing areas in Sri Lanka

Samples were analyzed for six minerals and it showed significant differences for three minerals (Calcium, Potassium and Magnesium) among analyzed six minerals (Table 3). Calcium (Ca) content

(38.95±12.07mg/100g) was significantly lower ($P < 0.05$) in flour samples obtained from Kandy district compared to those obtained from other four districts. However it did not differ significantly among samples obtained from Kegalle, Kurunegala, Matale, and Rathnapura districts. When compared the Potassium content among five areas, it did not show significant differences ($p > 0.05$) among samples obtained from Kurunegala, Matale, Kegalle and Rathnapura districts. However it showed significant difference with the lowest value of 28.22±3.57mg/100g in samples from Kandy.

Sodium content did not show significant differences ($p > 0.05$) among samples from five selected areas with mean of 50.06±30.53mg/100g.

Iron content also did not show significant differences ($P > 0.05$) with mean of 12.83±3.69 mg/100g, among samples obtained from Kandy, Kegalle, Matale, and Rathnapura districts.

With the mean of 3.47±2.54mg /100g , Zinc content was not significantly different ($p > 0.05$) within selected five district's Kithul flour samples. However Magnesium content showed significantly different ($p < 0.05$) among Kithul flour samples from five districts. Among analyzed six minerals Zinc showed the lowest amount as mean 3.47±2.54mg/100g. Calcium was showed highest mineral content 68.66±27.44mg/100g among other tested minerals.

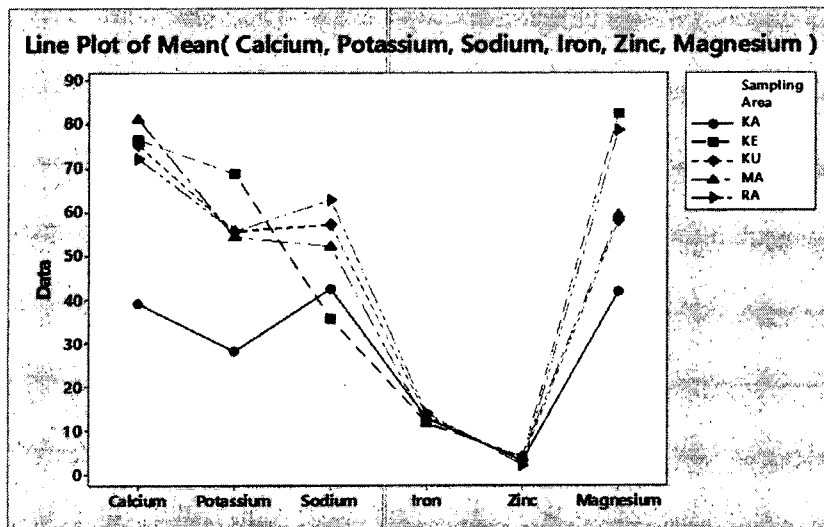
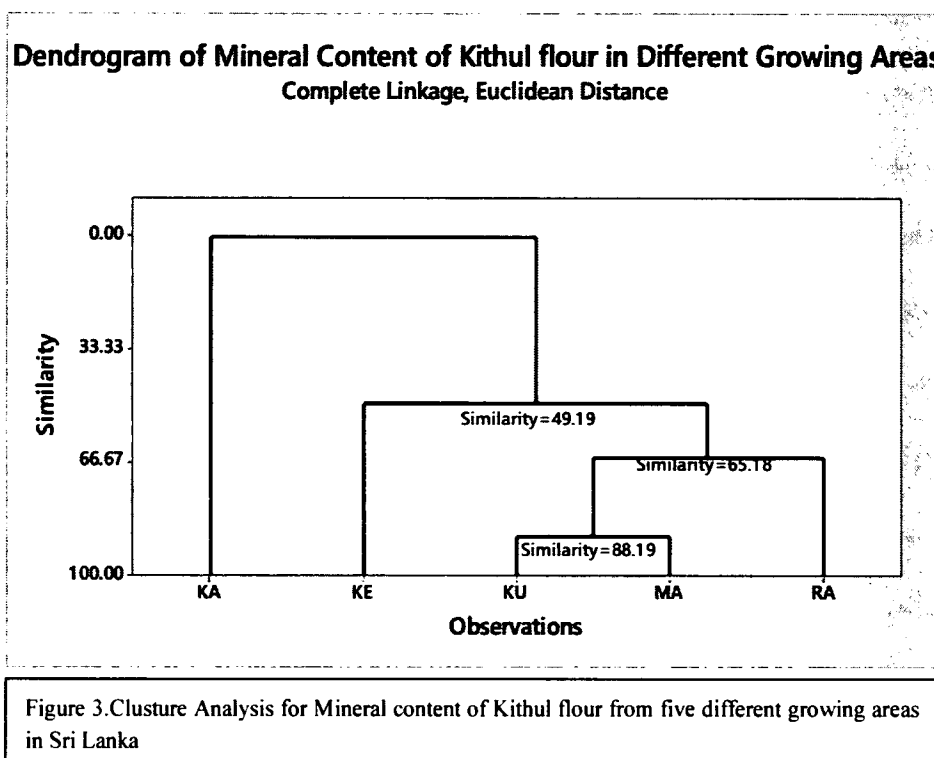


Figure2. Mineral content comparison of Kithul flour from five different growing areas in Sri Lanka

Standard deviation of mineral results showed high variance among thirty samples where mineral content of the flour could vary according to the growth stage, age of the tree, soil composition in the area, and tapping or non-tapping condition of the tree. Analyzed mineral content of Kithul flour samples was plotted in Figure 2. One correlation could be found out by statistical evaluation of mean values of mineral content of Kithul flour treatments. Magnesium content and Calcium content presented strong, positive, significant correlation ($r = 0.628, p < 0.05$) linkage.



Cluster analysis results are plotted in Figure 3. Mean values of mineral content in Kithul flour samples from five different growing areas, clearly produced three clusters as per the similarity (Figure 3). Kithul flour from Matale (MA) and Kurunegala (KU) presented a strong similarity level (88.19), while Rathnapura (RA) and were having next similarity level (65.18) with that cluster. Kegalle (KE) area linked with next similarity level (49.19) Kithul flour from Kandy (KA) district was presented different cluster with least similarity level (0.00) to other 4 districts. By results of cluster analysis, it could be observed that Kithul flour from different growing area not showed clear cut relationship on mineral content. These variations could be based on soil composition of the area, growth stage of the tree and Tapped or non-tapped condition.

IV. CONCLUSION AND FURTHER WORK

According to the statistical analysis flour samples from five different Kithul growing districts showed significant differences in proximate composition. Ash content ranged from 0.24% to 1.31%, while total lipid presented a

0.37 ± 0.07 g/100g (dry basis) mean value. Mean crude fibre content of samples was 1.06 ± 0.21. Kithul flour is not rich in protein which ranged from 0.92 to 1.09 g/100g (dry basis) but this is a very rich source for carbohydrate (87.14 ± 1.25) which provides main energy requirement of daily diet.

Mineral content of Kithul flour treatments showed significant differences for only three minerals (Calcium, Potassium and Magnesium) among analyzed six minerals. Calcium content of the Kithul flour was significantly lower ($p < 0.05$) in samples from Kandy (38.95 ± 12.07 mg/100g) compared to those from all other districts, while Potassium content was lower ($p < 0.05$) in flour from Kandy (28.22 ± 3.57 mg/100g) compared to samples from other four districts. All five samples had a considerable amount of nutritionally important trace elements Iron (Fe) and Zinc (Zn), with mean values of 12.84 ± 3.69 and 3.47 ± 2.54 mg/100g (dry basis), respectively. Mean concentrations of macro minerals, namely Sodium (Na), Potassium (K), Calcium (Ca), and Magnesium (Mg), were as

50.06±30.53, 52.51±20.78, 68.66±27.44, 63.93±27.12mg/100g respectively.

This study shows that Kithul flour samples obtained from five main growing districts are significantly different with respect to chemical composition except for Sodium, Zinc and Iron content, which could be important consideration for future food application when using composite Kithul flour from different growing areas.

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