PHYSICO-CHEMICAL PROPERTIES OF FLOUR FROM TAPPED & NON-TAPPED KITHUL (*CARYOTA URENS*) TREES IN KANDY, SRI LANKA

J A A C WIJESINGHE, I. WICRAMASINGHE, K.H SARANANDHA

Abstract: This paper describes comparison of physicochemical characterization of flour obtained from Tapped & Non-Tapped Kithul (*Caryota urens*) trees in Kandy, Sri Lanka. The protein content of tapped and non-tapped flour was 1.10% and 1.21% respectively while the total fat content was 0.36% and 0.37%. Though there was no any significant difference of moisture, protein, total fat and crude fiber, total starch among these two types of Kithul flour samples , it could clearly identify slight increment in above properties of non-tapped Kithul flour than tapped Kithul flour. Total starch content was 67.0% for Non-tapped Kithul flour while tapped flour showed 66.64%. In the case of Amylose content, tapped Kithul flour contained 28.45% while non-tapped flour showed 28.4% without any significant difference. The high moisture sorption of Kithul flour samples both tapped and non-tapped as 29.47 and 28.67 without any significant difference ($P>0.05$). The measurement of gelatinization temperatures of tapped and non-tapped Kithul flour treatments which were obtained by DSC were 76.17 °C and 77.32 °C respectively, while enthalpy for gelatinization of tapped and non-tapped Kithul flour treatments were 10.8 J/g and 11.45 J/g respectively. And also being high density flour (Tapped Kithul Flour: 0.71g/ml and Non-Tapped Kithul Flour 0.69g/ml) Kithul flour will be better thickener as well as a stabilizer in baking powders and as an emulsifier in the food industry. By considering all above similarities there is possibility to use Kithul tree for flour preparation after tapping process, and suggest that it could be useful to protect both tapping and flour industries by empowering Kithul Industry with rural economy in Sri Lanka.

Keywords: Tapped & Non-Tapped Kithul , (*Caryota urens*), Kithul flour, physicochemical characterization, DSC, Gelatinization.

Introduction: Starch is the most common organic compound on the Earth which as the main form of energy storage of fixed sunlight [1] through the photosynthesis by green plants. This polysaccharide which consists of amylose and amylopectin [2] accumulate in starch granules (amyloplasts) in various parts in the tree such as fruits, tubers, roots and bark [2].So carbohydrate play main role in human diet as primary energy supplier [3].Amylose and amylopectin play key role of characteristics of the starch [2].Having linear structure amylose form strong, steady, insoluble texture although branched amylopectin is rapidly dissolve in aqueous Systems [4]. Starch is essential ingredient not only for food industry as bulking, thickening, gelling, binding agent [1] as well as stabilizer, edible film former [2], but also in pharmaceutical, textile [3], Cosmetics, plastics, adhesives and paper industries [1].Most commercial manufactures overlook the Physico-chemical properties of comparative starches for their specific applications [5].However, existing few prominent starch sources could not fulfill high demand for industrial purposes [3]. Therefore it is needed to be discovered newer, commercial viable starch sources.

Palms are proper source for starch production which belongs to oldest families of plants on earth [6].Contemporary researchers pay their keen attention to discover novel sources of starch, which exist in the wild [6].Kithul (*Caryota urens*) is a better response for this requirement ,which is still keep as semi-wild species [7].This palm is native for India, Malaysia and Sri Lanka [8].The bark yields around 100 kg -150 kg of pith per palm which used to preparation of flour [8].The main usage of Kithul in current society is production of sap for toddy and jiggery [9].So then common names for Kithul are Toddy palm and Jaggery palm [10].According to the Indian scientist quality of flour from *Caryota urens* to be equal to the best sago of commerce extracted from *Metroxylon sagu rottb* [7].

For the production of sap, flower of Kithul is tapped. During the tapping period starch in the tree converted in to sugar and transport through pholems. Because of this in the tapping period starch storage in the bark becomes very low. After the termination of the tapping activity again starch begins to accumulate in the bark [9]. However people believe that flour from non-tapped trees have better quality than tapped trees. For the flour extraction process the tree is subjected to debarking [11], which meant the end of the life of tree.

Therefore production of flour from Kithul tree obstructs the existing Kithul industries such as toddy and jaggery. To empower the Kithul flour production ,overcoming above problem simultaneously use of tapped tree for flour preparation will be ample solution , if there is not any significant difference among Physico-chemical properties of both tapped and non-tapped Kithul flour .

The aim of the present study is to comparison various physicochemical characterization of both tapped and non-tapped Kithul (*Caryota urens)* flour with an attempt to find out the suitability as a new flour source for industrial use which can reduce the burden on other common starch sources.

Materials And Methods:

Sample collection: Flour preparation center (Sashika products) in Theldeniya, Kandy from central province of Sri Lanka which has registered in export agriculture department was selected for the sample collecting for this study. Three Kithul flour samples were collected from each type (Tapped and non-tapped) from the above flour producer.

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

Solubility test: A 1g of Kithul flour was weighed and poured into a beaker containing 1ml, 2ml, 10ml, 1L and 10L distilled water at 30°C and was stirred, and the solubility was observed. Same procedure was repeated using 65% alcohol as a solvent. The procedures were repeated for all six samples [4].

Iodine test: Using Musa et al, 2011 [4] starch identification test, 1g of starch was boiled with 15ml of water and allowed to cool. A few drops of 0.1N Iodine solution were added to 1ml of the mucilage and the colour changes recorded.

Determination of pH: 10g of Kithul *(Caryota urens)* flour was weighed into 15ml distilled water and was properly mixed. The mixture was poured into boiling distilled water to make up 100ml of slurry. The slurry was allowed to cool. Using a pH meter (Hach HQ11D, UK), the pH of the slurry was measured. Same was done for all the samples [4].

Moisture Content: One gram of each flour sample was weighted in a dish and reading was taken by placing in the Infra-red moisture content testing machine (ULTRA X) [3].

Proximate analysis: Total fat, protein (N x 6.25), ash and crude fiber content were determined according to AOAC (1990) [12] methods. Carbohydrate contents were determined by difference sum of above categories.

Amylose Determination: Amylose content of Kithul flour was determined in three steps using simple iodine colorimetric method as described by B.O. Juliano (1971) with slight modifications [13].

Amylopectin: Amount of amylopectin was calculated by subtracting the amylose content from the starch content and expressed as g/100g of dry weight [14].

Total Starch Determination: Starch content was determined by the complete acid hydrolysis method [15].Flour sample of 2.5g was suspended in a mixture of 200ml of water and 20ml of HCl acid (specific gravity 1.125).The mixture was heated in a flask provided with a reflux condenser for 2.5 hours. Contents were cooled, and neutralized with NaOH (5N).Volume was made to 250ml and sugar formed was determined as dextrose by Lane and Eynon reducing sugar estimation method. The dextrose multiplied by 0.9 was taken a starch [16].

Determination of flour density:

Bulk density**:** Bulk density of the flour was determined according to the method of Musa et al.(2011) [4] with slight modifications**.**20g each, of individual flour respectively were poured through a short-stemmed glass funnel into a 250ml graduated glass cylinder and the volume occupied by the flour was read and the bulk density calculated in triplicate.

Tapped density: Graduated cylinder containing 20g of flour was dropped on a bench 50 times from a height of about 20mm and the respective volumes recorded. Same was done for all samples and the tapped densities was then calculated in g/ml[4].

Carr's Index: The difference between the tapped and bulk density divided by the tapped density was calculated and ratio expressed as a percentage [4].

Hausner ratio: Hausner ratio was calculated by taking the ratio of tapped density to bulk density for all the samples [4].

Determination of moisture sorption capacity: Moisture sorption capacity was determined by method described by shiihii et al (2011) [3].Each dried flour samples were spread evenly in Petri dishes; the Petri dish was placed in a desiccator with 98% relative humidity at room temperature. The samples were periodically weighed until a constant weight was attained. The percentage increase in weight as calculated and taken as the moisture sorption capacity. The above experiments were repeated thrice and the mean of the readings was recorded.

Differential scanning calorimetry (DSC): Thermograms for Kithul flour from tapped and non-tapped trees were taken by DSC (Model DSC TA instrument Q 200,USA).Flour was weighed on to the aluminium DSC pan and distilled water was added with micro syringe for 50% (w/w) mixture. Pan was sealed and allowed to stand for 1hr at room temperature. The scanning temperature range and heating rate were 30-140 °C and 5 °C/min, respectively, using empty pan as reference [16]. The onset temperature (To), peak temperature (Tp), conclusion temperature (Tc), and gelatinization enthalpy (ΔHG) were recorded.

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).

Results And Discussion: Sample collection for this study was done from the Flour preparation center (Sashika products) in Theldeniya, Kandy from central province of Sri Lanka which has registered in export agriculture department. To minimize climatic variables which could be affected on the flour quality, the same area was selected for the sample collection. And also it was assumed that use of all samples which were collected from same producer who could be reliable for provide flour without adulteration ,would be provided flour which has prepared in same process.

The two flour types as tapped Kithul and non-tapped Kithul flour were odourless and pale yellow in colour. And these were insoluble in water and 65% ethanol with positive respond for Iodine test and acidity test. According to the Muazu,J et al(2011) [4] the starches were all positive for Iodine test [17]. pH value showed very similar values according to the Table 1 which showed acidic characteristics by bellowing pH 7.Acidic food has natural protection by microbians. So this pH value could be advantage for long shelf life. On the other hand the starches within the pH range of 3-9 mostly used in the pharmaceutical, cosmetics, as well as food industries. However the pH were all samples In between the acceptable limit of 4.5-8 align with Pharmaceutical industry too [18].

Table 1: Comparison of results on identification test of Kithul flour obtain from Tapped and non-tapped trees

Identification Test	Non-tapped Kithul flour	Tapped Kithul flour
Odour	odourless	odourless
Colour	Pale yellow	Pale yellow
Solubility Test	Insoluble	Insoluble
Iodine Test	Positive	Positive
pH	6.4 ± 0.0	6.5 ± 0.2

The proximate composition of the tapped and non-tapped Kithul flour shown in Table 2. The result obtained in this study showed that moisture content was 13.64% and 13.75% in tapped and non-tapped Kithul flour respectively. The moisture content of flour plays a considerable role in the physical and mechanical properties as well as shelf life of the food. However, it depends largely on the method, degree of drying, and the relative humidity in the environment [19]. The protein and total fat contents of the above flour treatments were not significantly different (P>0.05). However, the protein content of tapped and non-tapped flour was 1.10 and 1.21 respectively while the total fat content was 0.36% and 0.37% in tapped and non-tapped Kithul flour respectively. Though there was no any significant difference of moisture, protein, total fat and crude fiber among these Kithul flour samples, it could clearly identify slight increment in non-tapped Kithul flour than tapped

Table 2: Variations on Chemical composition of Kithul flour obtain from Tapped and non-tapped trees

Sample Name	Moisture Content %	Crude Protein (g/100g db)**	Total Fat (g/100g db)	Crude Fibre (g/100g db)	Ash Content (g/100g db)	Carbohydrate (By Difference)
Tapped Kithul Flour(db)*	13.64± 0.91^{a}	1.1±0.17 ^{a}	0.36±0.03 ^{a}	1.22± 0.02^{a}	0.43±0.08^{a}	83.25± 0.28^{a}
Non-Tapped Kithul Flour(db)*	13.75± 0.35^{a}	1.21± 0.08^{a}	0.37±0.03 ^{a}	1.35± 0.32^{a}	0.37±0.11^{a}	82.94± 0.31^{a}

db = Dry basis.
* Data are the average of three repetitions ±standard deviation. The values in a column followed by the same letter are not statiscally different at a significance level of 5%. *** N×6.25.

Kithul flour. Carbohydrate content has calculated by difference of other proximate parameters as per the Table 2.So it shows slight decreases of non –tapped Kithul flour (82.93) than tapped Kithul flour (83.25) which was not in significant. This factor not meant non-tapped Kithul flour has less carbohydrate than tapped Kithul flour. Because of the calculation method carbohydrate content depend on other parameters, such as moisture content, ash, crude fiber etc. which not showed the actual degree of carbohydrate. It revealed by total starch content (Table 3) with value of 67.5%% for Non-tapped Kithul flour while tapped flour showed 66.64% of total starch content. Though it has not significant different (P>0.05) non-tapped Kithul flour showed excessive amount than tapped Kithul flour. In the case of Amylose content, tapped Kithul flour contained 28.45% while non-tapped flour showed 28.4% without any significant difference.

Total starch content was determined using two steps as acid hydrolysis and determined the reducing sugar content. The Lane-Eynon method was used for determining the concentration of reducing sugars in the samples. A burette was used to add the flour solution being analyzed to a flask containing a known

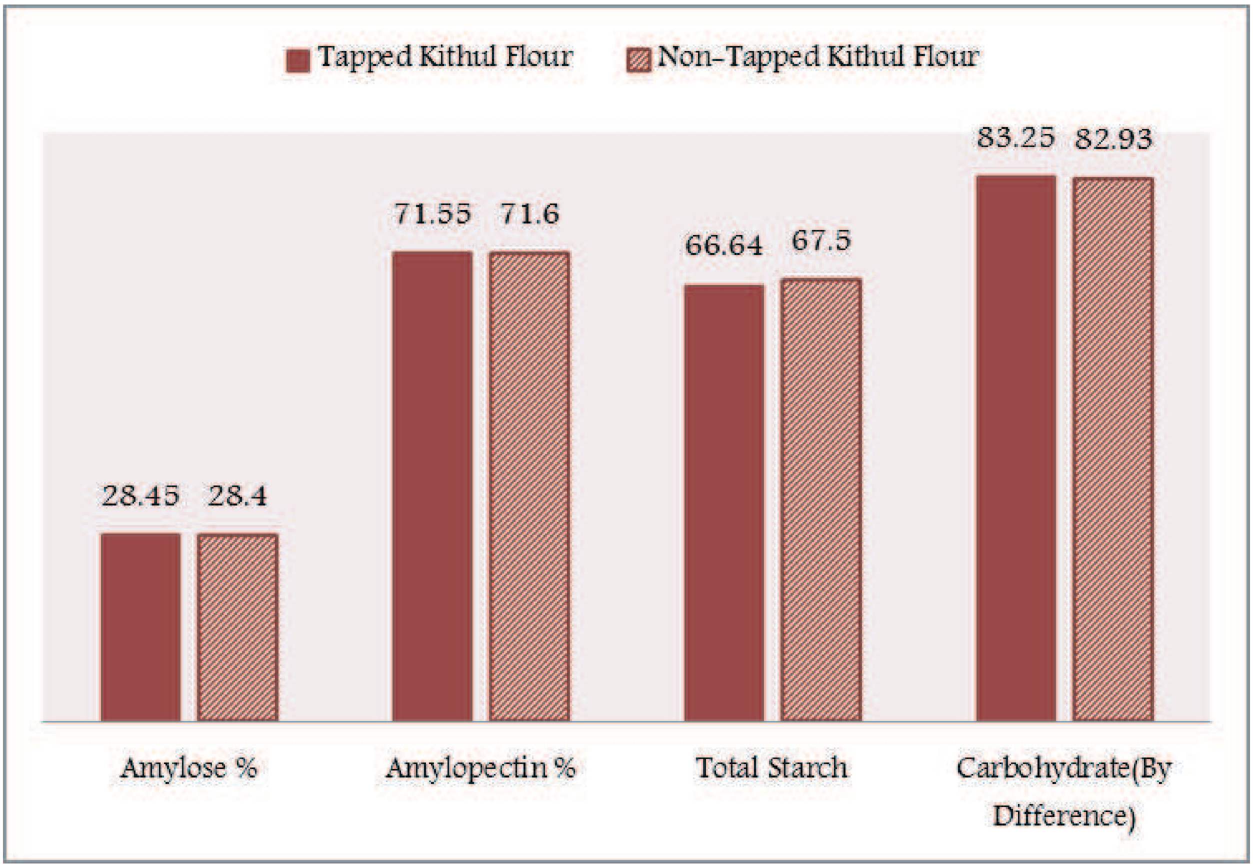

Table 3: Variations on Amylose, Amylopectin and total starch of Kithul flour obtain from Tapped and non-tapped trees			
Sample Name	Amylose**	Amylopectin **	Total Starch
Tapped Kithul Flour(db)*	28.45±0.18[a]	71.04 ± 0.18[a]	66.64± 6.58[a]
Non-Tapped Kithul Flour(db)*	28.40±0.30[a]	71.60 ±0.30[a]	67.00± 11.07[a]

db = Dry basis.
* Data are the average of three repetitions ±standard deviation. The values in a column followed by the same letter are not statiscally different at a significance level of 5%.** In base of 100% of starch.

amount of boiling copper sulfate solution and a methylene blue indicator. The main disadvantage of this method is the results depend on the precise reaction times; temperatures and reagent concentrations used [14] .There for personnel errors must be carefully controlled. Tapped Kithul flour contained 66.64% while non-tapped Kithul flour showed 67.0 % (Table 3).There was no any significant difference (P>0.05) among tapped and non-tapped Kithul flour samples. So it is revealed basically that tapping procedure not affect much on starch quality of Kithul flour (Figure 1).

It again proved through Amylose and Amylopectin values. Usually, the functional properties are regulated by amylose and amylopectin content of the starch [20].As well as parameters are key quality considerable points of starches, which could impact multiple quality characteristics of baked foods, and greatly influence important functional properties such as ability to form pastes or gels [21].

Kithul flour contained medium amylose content as 28.45% in tapped Kithul flour and 28.4 % in non-tapped flour (Table 3). Here also tapped Kithul flour contained very slight increment in amylose value as 0.05 than the non-tapped flour. This also indicated that there was not any issue for quality parameters in Kithul flour by tapping process. In the sense of both tapped and non-tapped Kithul flour have not significant difference among amylose and amylopectin values functional properties of these two types of Kithul flour could be mostly similar.It again complying with results of functional properties of both tapped and non-tapped Kithul flour (Table 4).

Bulk density is depended upon the particle size of the samples. Bulk density is a measure of heaviness of a flour sample. It is important for determining industrial requirements as packaging, material handling and utilization in wet processes in the food industry [17]. There was no significant difference (p>0.05) in the tapped densities of both tapped and non-tapped Kithul flour samples based on the data of Table4 .Due to flours with high bulk densities are used as thickeners in food industry, both tapped and non-tapped Kithul flour studied could be used as a thickener [22].

Table 4: Variations on functional properties of Kithul flour obtain from Tapped and non-tapped trees

Parameter	Non-Tapped Kithul Flour	Tapped Kithul Flour
Bulk Density(db)*	0.69 ± 0.03^{a}	0.71± 0.03^{a}
Tapped Density(db)*	0.90± 0.04^{a}	0.91± 0.04^{a}
Carrs Index(db)*	23.75± 0.38^{a}	22.44± 1.33^{a}
Hausner ratio(db)*	1.31± 0.01^{a}	1.28±0.02^{a}
Water sorption (db)*	28.67± 0.58^{a}	29.47± 0.40^{a}

db = Dry basis.

* Data are the average of three repetitions ±standard deviation. The values in a raw followed by the same letter are not Statistically different at a significance level of 5%.

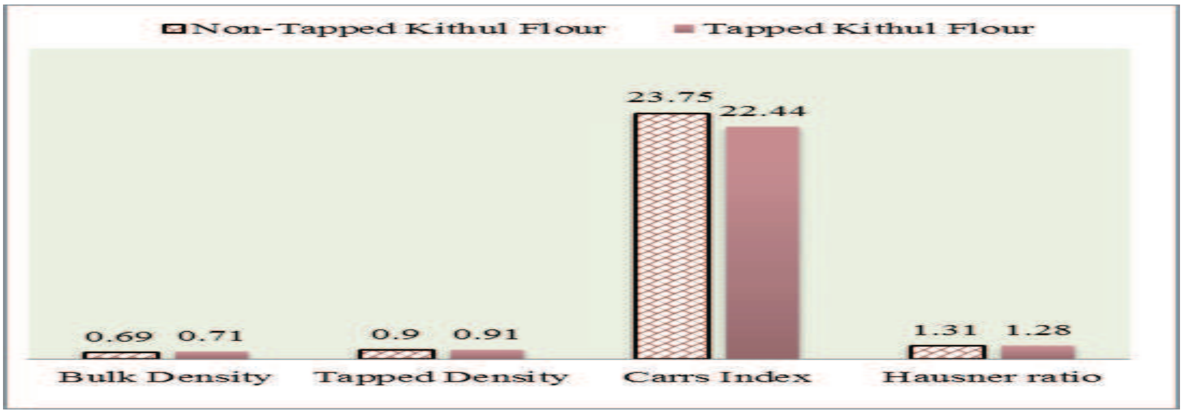

Figure 2 Comparison of Density of Tapped (T) and Non-tapped (NT) Kithul flour

Table 5: Variations on water sorption value of Kithul flour obtain from Tapped and non-tapped trees with the time

Sample	1hr	2hr	3hr	22hr	36hrs	48hr	72hr
T	9.94±1.05	11.27±0.64	12.92±1.06	22.18±0.52	22.43±0.46	29.47±0.4	29.47±0.4
NT	7.87±0.04	10.17±0.55	12.13±0.54	21.64±0.12	21.88±0.11	29.18±0.67	29.18±0.67

Each value represents the means of three estimations of three samples each tapped and non-tapped Kithul flour.
T for represent the Kithul flour samples from tapped trees and **NT** stands for Kithul flour samples from non-tapped trees.

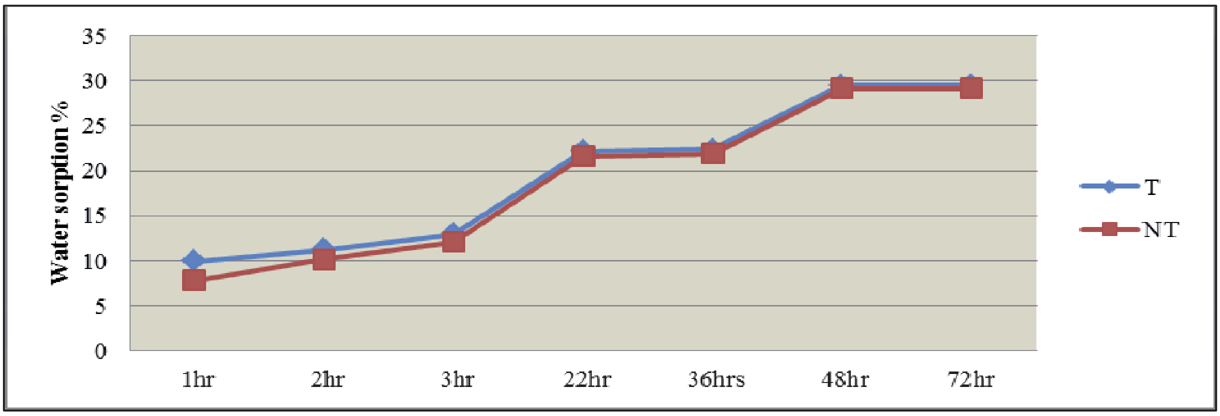

Figure 3.Water sorption behaviour of Tapped (T) and Non-tapped (NT) Kithul flour vs time

The parameters called Carr's index and Hausner ratio predict the flow and compressibility of powders [17], which used in pharmaceutical industry. Based on the consecutively may show up susceptibility to
bulk and tapped densities, Kithul flour samples of tapped and non-tapped were obtained Carr's index as 22.44 and 23.75 in sequence(Figure 2).
Hausner ratio values obtained in this study for both tapped and non-tapped Kithul flour samples were 1.28 , 1.31 respectively. As per the literature, Hausner ratio above 1.2 and Carr's index above 23% do not indicate good flow or good compressibility [17]. Though there was no any significant difference among both types of Kithul flour samples with respect to Carr's index and Hausner ratio, tapped Kithul flour samples was indicated more suitable values as good flow and good compressibility than non-tapped Kithul flour as per the Muazu et al(2011) [17].
Moisture sorption capacity is attribute to implying sensitiveness of starch is to atmospheric humidity which responsible for physical stability [4] of the starch and it assists to forecast some physicochemical properties [3].The high moisture sorption of Kithul flour samples both tapped and non-tapped as 29.47 and 28.67 (Table 4) consecutively may show up susceptibility to moisture affected properties [23].
Variation of the Moisture sorption value with the time is shown in the Figure 3 based on the data in Table 5.It represents the same behaving pattern for both types of flour samples with similar value for the final reading.
Gelatinization senses increasing randomness in the structure, decreasing crystallization regions of starch/water system by breaking down intermolecular bonds with increasing temperature, and Hydrogen bonding sites absorb more water. Then ultimately loss of birefringence is occurred [24]. Gelatinization temperature is key parameter for processing and serves to identify the different starches.

Table 6: DSC transition parameters of Kithul flour obtain from Tapped and non-tapped trees with the time				
Sample Name	Onset Temperature/ °C *	Peak Temperature/ °C *	Conclusion Temperature / °C *	Gelatinization enthalpy (J/g) *
T(db)	71.26±0.12[a]	76.17±0.10[a]	87.75±0.01[a]	10.8±0.50[a]
NT(db)	72.79±0.04[a]	77.32±0.50[a]	87.08±0.04[a]	11.45±0.14[a]

db = Dry basis.
* Data are the average of three repetitions ±standard deviation.
The values in a column followed by the same letter are not Statistically different at a significance level of 5%.

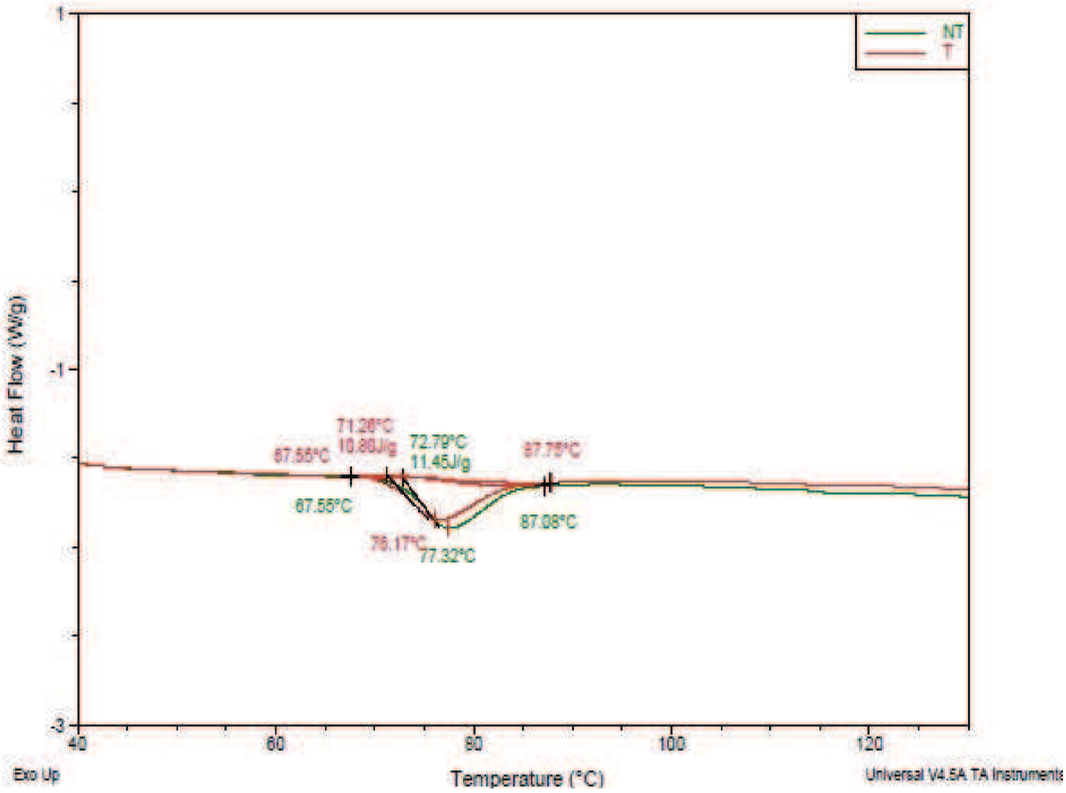

Figure 4 Gelatinization DSC curves of Kithul flour of Tapped (T) and non-tapped (NT)

Differential Scanning Calorimetry (DSC) is broadly utilized in the food industry to study behaviour of starch-water system with interactions with lipid, protein and other starch components. The first application of DSC to the study of starch gelatinization was carried out by Stevens and Elton in 1971 [25].The measurement of gelatinization temperatures of tapped and non-tapped Kithul flour treatments which were obtained by DSC were 76.17 °C and 77.32 °C respectively (Table 6). Endothermic peaks of the DSC results due to the resolved gelatinization of tapped and non-tapped Kithul flour treatments were 10.8 J/g and 11.45 J/g respectively (Figure 4). Both flours exhibited their own characteristic by gelatinizing temperature without any significant difference (P>0.05) according to the results showed in Table 6.

Conclusion And Further Work: During the tapping process, Starch is converted to sap and transport via phloem tubes. Therefore, in the tapping period trees are deficient in flour. However, after termination of production of sap, starch can be re-accumulated in the pith. Though the village people believe that Non-tapping trees are more suitable for collecting starch this study revealed that there was no any significant different in main Physico-chemical properties among tapped and non-tapped Kithul flour. Nevertheless as quantity wise it could be differences among the tapped and non-tapped Kithul trees align with the allocated time to re-accumulate after cessation of the

Tapping. For further studies comparison of quantities both tapped and non-tapped will be provide perfect answer for suitability of use of tapped trees for flour production which could be helped to empower the Kithul industry by protecting both tapping industry as well as flour industry .

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J A A C Wijesinghe/ I. Wicramasinghe/ K.H Saranandha
/Department of Food Science & Technology/
University of Sri Jayewardenepura/Sri Lanka/
Food Research Unit/Gannoruwalucky.research@yahoo.com/
indiraw2002@yahoo.com/saranandahewage@yahoo.com