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Macronutrient Composition, Functional and Textural Properties of Selected Traditional Sweetmeats of Sri Lanka

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ABSTRACT

Purpose: *Sri Lankan traditional sweetmeats occupy a special place in regular consumption, festivities and religious offerings. Sweetmeats are popular food items since ancient times, however, their compositional information are limited. The objective of this study is to provide information on macro-nutrients, energy intake, antioxidant potential and bioactive compounds of selected sweetmeats.*

Research Method: *Twenty-five sweetmeat prepared with standardized recipes were analyzed for major nutrients using standard analytical methods. Methanol (80%, v/v) extracts of these products were evaluated for antioxidant potential (AP) by Ferric Reducing Antioxidant Potential (FRAP), 2,2-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) scavenging activity and 2,2'-diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging assays.*

Findings: *Almost all tested sweetmeats were energy-dense foods. Among the deep-fried foods, Beraliya kevum had the highest fat content 28.23±1.06 %. Kos eta aggala (68.05±1.30%) reported the highest carbohydrate content and Unduwalalu had the highest protein content (8.70±0.33%) among all the sweetmeats. The AP of Hal helapa made of rice flour, finger millet flour and Vateria copallifera was significantly ($p<0.05$) higher compared to all other sweetmeats; 222.44±5.34 mM TEAC/g dry matter by DPPH assay and 240.28±5.62 mM TEAC/g dry matter by ABTS assay. Stable polyphenolic compounds and Maillard reaction products generated during high temperatures of processing may be contributing to high AP.*

Originality/ Value: *These findings are useful to enhance the consumer awareness in making food choices based on the major nutrients and antioxidant potential. These data can be used to improve the health-related parameters of traditional sweetmeats by reformulating with healthy ingredients and meeting the health concerns of consumers.*

Keywords: *Antioxidant activity, Energy, Macronutrients, Sri Lanka, Traditional sweetmeats, Trolox equivalent*

INTRODUCTION

Traditional foods play an important role in defining identity, culture, heritage, behavior, knowledge systems and trans-generational knowledge transfer of human population groups (Viwatpanich, 2012). Food being a basic necessity for existence of human life, the sources and the ways of preparation are firmly rooted in the customs and traditions of the people living in different geographical locations. The food culture in Sri Lanka is unique; present day foods

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represent a perfect blend of traditional foods with several non-traditional, foreign foods and preparation types. Traditional foods are important components of the diets of Sri Lankans since ancient times and still remains, may have been evolved with time.

Consumption of sweet items (sweetmeats) in between meals or after the main meals is common since past and has a special place in the traditional diet (Perera *et al*., 2010). Sweetmeats differ from desserts because they are widely used for snacking, served during special ceremonies/ occasions and also shared as a gesture of hospitality in daily life. With the strong fondness for sweet food items, traditional sweetmeats are popular among locals as well as foreign visitors because of the variety they offer in terms of appearance, texture, taste, and sometimes the associated health benefits of the ingredients. Although not very distinct, two categories of sweetmeats can be seen in Sri Lankan food culture. One group is the distinctly Sri Lankan traditional sweetmeats that are prepared using local or indigenous ingredients and traditional preparation methods and utensils that are not seen in other cultures and cuisines. Some of the ancient records and evidence support their existence in the past. The other group of sweetmeats are the ones that has been introduced by non-local food cultures as a result of international trade relationships, forceful occupation and also by colonization of three European nations; Portuguese, Dutch and English. These foods have become Sri Lankan traditional sweetmeats but with some evolution with time to include local ingredients. Most importantly, sourcing, and preparation of ingredients and foods has been practiced for many years with a significant component of our traditional knowledge system playing a key role in keeping trans-generational knowledge transfer on these foods (Ananthanarayan *et al*., 2019).

As the name implies, sweetmeats are sweet in taste and comprised of different types of traditional sweetening agents in addition to the flours of cereals, legumes and other seeds with minor ingredients such as nuts and spices (Mihiranie *et al.,* 2019). Widely utilized sweetening agents are liquid treacle and solidified jaggery processed from sap (*toddy*) obtained by tapping the young inflorescence of *Caryota urens* (*Kithul*) or *Cocos nucifera* (coconut) palm. Since the latter part of last millennium, cane sugar and/or corn-starch-based sugar (brown or white) became a major sweetening agent even for traditional food primarily due to dwindling supply of palm-based products that could not satisfy the increasing demand. Rice is the prime flour source for traditional sweetmeat that is from traditional varieties and processed further with heat; roasting or steaming. Flours of other local grains such as green gram or mung bean (*Phaseolus aureus*), black gram (*Phaseolus mungo*), finger millet (*Eleusine coracana*), seeds of cycas (*Cycas circinalis*), *hal* (*Vateria copallifera*) and sesame (*Sesamum indicum*) and dry fruits of *beraliya* (*Shorea megistophylla*) are often mixed with rice flour depending on the product requirement. Wheat flour has been replaced many of these flour sources during last several decades (Mihirani *et al*., 2020).

Almost all the ingredients used in traditional sweetmeats are local to Sri Lanka with some variation depending on the flora and fauna native to eco-regions which has direct relationship with the geographical factors. They are less refined, plant products rich in plant secondary metabolites and economically affordable because of the abundance in the local area, however could be seasonal and not available throughout the year. Similarly, these ingredients can be considered as organic, less processed, and natural without chemical preservatives, in the present-day food industry terms. Ingredients used in the commercial products are replacements that provide function in the products; e.g function of starch in unpolished rice flour in traditional formula is replaced with starch of white wheat flour or blends of rice and wheat flour, sweetening and browning function of palm treacle/jaggery is replaced with high fructose corn syrup or cane sugar.

Similar to many other developing countries, urban and sub-urban population of Sri Lanka have passed through a considerable lifestyle

changes with the population growth, so did the clear transition in the physical activities and food consumption habits. Increasing house hold income, purchasing power and food nostalgia may have caused frequent inclusion of sweetmeat in daily meals for snacking or after meals. There has been a growth in the cottage-style and island-wide large-scale sweetmeat production making those products widely available to the consumer in each street corner. Rise of non-communicable diseases such as type II diabetes, coronary heart disease and metabolic syndrome has become prevalent in Sri Lanka mainly in the urban and sub-urban populations (Arambewela *et al.,* 2018) making it worthwhile to revisit types of foods other than main meal items and their compositions in detail to understand possible paths for corrective actions.

The present study was carried out to investigate the levels of macronutrients, energy, antioxidant potential, and level of phenolic compounds of 25 traditional sweetmeats popular among Sri Lankans and prepared with local ingredients. Instrumental texture properties of the products were also investigated.

MATERIALS AND METHODOLOGY

Selection of traditional sweetmeats

A field survey was conducted in the Southern, Central and Sabaragamuwa provinces of Sri Lanka to identify traditional sweetmeats known to the people. Of the 65 identified sweetmeats, 25 most popular traditional sweetmeat items which can be formulated with available local raw materials in present day were selected for the study. Table 01 represents these 25 selected traditional sweetmeats and the ingredients used in their formulations. The selected traditional sweetmeats included, deep fried (No. 1 to No. 10) and non-deep fried (No. 11 to No. 25) food items.

Raw materials and chemicals Raw materials

***Finger millet*:** A local variety of finger millet (*Eleusine coracana*) seeds (2 Kg from each farmer) was purchased from three farmers in the Central province of Sri Lanka. A composite sample of all 3 was taken, washed in potable water, drained and sun-dried for 4 hours. Finger millet flour was obtained by using a home-style grinder (Black and Decker, USA) followed by sieving through a 355 µm aperture sieve.

***Rice**:* Traditional red rice (*Oryza sativa*, variety BG 367) was purchased from the Department of Agrarian Development, Western province in Sri Lanka. Clean ready-cook rice grains were soaked in water for 3 hours (1:3 w/v) and extra water was drained off. Rice flour was obtained by milling wet rice using a home-style grinder (Black and Decker, USA) followed by sieving through a 355 µm aperture sieve.

***Pulses*:** Green gram (*Vigna radiata*), horse gram (*Macrotyloma uniflorum)* and black gram (*Vigna mungo*) were purchased from the local market. Green gram seeds and horse gram seeds were washed with potable water and soaked (1:3, w/v) overnight. Drained seeds were roasted (with the seed coat, on a metal griddle, temperature (approximately 160 ^{o}C for 10 minutes) and ground using a household mechanical grinder (Black and Decker, USA). A thick paste of black gram was obtained by soaking overnight, removing seed coat and grinding with small amount of water.

Vateria copallifera seeds: The fruits of *Vateria copallifera* (or *Hal*) were collected from five border villages of Sinharaja rain forest (6.3578° N, 80.4890° E) in Sri Lanka, during the month of August 2018. Five fruiting plants in each village were randomly selected and 10 fruits from each tree were made into a composite sample. Seeds removed from the fruits were scraped to obtain 2-8 mm particles using a stainless-steel scraper. For debittering, one kilogram of Vateria seed scrapes was loosely packed in a jute bag and placed overnight in a water (pH 6.9) stream with a velocity maintained at 70 mL/sec.

Table 01: Ingredients used in the formulations of selected 25 sweetmeats

S/N	Common traditional name	Major cereal/grain sources	Other ingredients
		Deep-fried sweetmeats	
1	*Aasmi*	Rice flour	Brown sugar, Kithul treacle, coconut milk, water extract of Dawul kurundu leaves
2	*Athirasa*	Rice flour	Brown sugar, Kithul treacle
3	*Kevum-Beraliya*	Powder of dried Beraliya flowers & rice flour	Brown sugar, Kithul treacle
4	*Kevum-Hendi*	Rice flour	Brown sugar, Kithul treacle, scraped coconut
5	*Kevum-Konda*	Rice flour	Brown sugar, Kithul treacle, cumin
6	*Kevum-Kollu*	Roasted horse gram flour & rice flour	Brown sugar, Kithul treacle, turmeric, coconut milk
7	*Kevum-Mung*	Roasted green gram flour & rice flour	Brown sugar, Kithul treacle, turmeric, coconut milk
8	*Kevum-Naran*	Roasted green gram, rice flour	Brown sugar, Kithul treacle, scraped coconut, turmeric, coconut milk
9	*Kokis*	Rice flour	Brown sugar, turmeric, coconut milk
10	*Undu walalu*	Black gram & rice flour	Brown sugar, Kithul treacle, turmeric, coconut milk
		Non-deep-fried sweetmeats	
11	*Aggala-Badi haal*	Roasted rice flour	Brown sugar, Kithul treacle, pepper
12	*Aggala-Dried rice flour*	Flour obtained from dried and roasted cooked rice	Brown sugar, Kithul treacle, scraped coconut
13	*Aggala-Habalapethi*	Rice flakes (*Habalapethi*)	Brown sugar, Kithul treacle, scraped coconut
14	*Aggala-Kos eta*	Roasted jack seeds	Brown sugar, Kithul treacle, scraped coconut
15	*Aggala-Thala*	Sesame seeds	Jaggery, scraped coconut
16	*Aluwa*	Roasted rice flour	Brown sugar, Kithul treacle
17	*Dodol*	Rice flour	Brown sugar, Kithul treacle, coconut milk
18	*Gotu pittu*	Rice flour	Brown sugar, Kithul treacle, scraped coconut
19	*Helapa-Hal*	Scrapes of Vateria copallifera, rice flour & finger millet flour	Brown sugar, Kithul treacle, scraped coconut
20	*Helapa-Kurahan*	Finger millet flour	Brown sugar, Kithul treacle, scraped coconut
21	*Imbul kiribath*	Raw rice	Brown sugar, Kithul treacle, coconut milk
22	*Kiri roti*	Rice flour	Brown sugar, Kithul treacle, coconut milk
23	*Laveria*	Roasted rice flour	Brown sugar, Kithul treacle, scraped coconut
24	*Welithalapa-Madu*	Rice flour & dried Cycas seed flour	Brown sugar, Kithul treacle, scraped coconut
25	*Welithalapa-Rice*	Rice flour	Brown sugar, Kithul treacle, scraped coconut

Shorea megistophylla (Beraliya) fruits: Dried Shorea fruits were collected from two border villages of Sinharaja rain forest in Sri Lanka, during August 2018. Collected dried Shorea fruits were ground and sieved through a 355 µm aperture sieve to obtain fine powder.

***Dawul kurundu (Neolitsea cassia) leaf extract*:** *Dawul kurundu* leaves were collected from Kalawana area in the Sabaragamuwa province. Clean leaves were pulverized with water (1:2, w:v) by manually and strained through Maslin cloth to get the thick viscous leaf extract.

Sweetening agents: Fresh *Kithul* treacle was obtained from a producer in the Kothmale area of the Central province. Brown sugar was purchased from a local retail store in the Central province.

Other minor ingredients including regular coconut oil, cardamom (*Elettaria cardamomum*), vanilla (*Vanilla orchids*), cumin (*Cuminum cyminum*), turmeric (*Curcuma longa*), eggs, coconuts , cashew (*Anacardium occidentale*), sesame (*Sesamum indicum*), *Habalapethi* (made from rice), and table salt were purchased from the local retail stores in the Western province. All ingredients were bought in a bulk quantity on a single purchase to minimize variation in ingredients used in the products.

Chemicals

All chemicals and reagents were analytical grade and purchased from Sigma Chemicals Co. (St. Louis, USA).

Process standardization and sample preparation

All sweetmeat recipes went through standardization according to the modified method of Murali and Arun (2017) that include the 3 steps of: recipe verification, product evaluation and quantity adjustment. In brief, 5-10 recipes for each food item were collected from different households of the Southern, Central and Sabaragamuwa provinces. In the verification, same sweetening agents were used and the ingredients in solid and liquid forms were measured in grams and milliliters, respectively. For the same sweetmeat, when the recipe uses varying amounts of the same ingredients, an average value was used if the deviation between specified amount was less than 10%. For the recipes with deviation larger than 10%, the food products were prepared according to the given recipe and the recipe that resulted in products with good sensory properties; texture, taste and colour were selected based on the sensory assessments carried out by the women in the villages who are well-experienced in preparing these traditional sweetmeats. Standardized formulations for these 25 sweetmeats are presented in Table 02. Main processing steps and process conditions followed for these sweetmeats are presented in Table 03. Each product was prepared as 3 batches, and 25 products were packed in triple laminated aluminum bags upon cooling, stored at ambient temperature and used as samples for macronutrient analysis on the following day of preparation.

Analysis of macronutrient content and calorie value of selected sweetmeat samples

Prepared sweetmeat products were analyzed for the contents of moisture by oven drying method, fat by Soxhlet extraction using hot (40 ^{o}C – 60 ^{o}C) petroleum ether, crude protein by micro Kjeldahl method (AOAC, 2012) and total carbohydrates by Anthrone method (Buckan, 2015). Caloric value of 100 g of product was calculated using the following formula as described by Schakel *et al*. (1997),

$$Energy\ (kcal) = (4\ kcal/g\ Protein \times g\ Protein) + (9\ kcal/g\ Fat \times g\ Fat) + (4\ kcal/g\ Carbohydrates \times g\ Carbohydrates) \quad (1)$$

Table 02: Ingredients required for the standardized recipes of selected traditional sweetmeats (For the preparation of food mixture using 100 g of main flour source/ ingredient for each product)

Amounts of required ingredients																												
Name of the sweetmeats	Raw rice (g)	Roasted rice flour (g)	Unroasted rice flour (g)	Green gram flour/pieces (g)	Wheat flour (g)	Black gram (g)	Horse gram (g)	Dried cooked rice flour (g)	*Beraliya* flour (g)	Cycas seed flour (g)	Scraped Vateria seeds (g)	Finger millet flour(g)	Scraped coconut (g)	Jack seeds (g)	*Habalapethi* (g)	Brown sugar (g)	*Kithul* treacle (mL)	Coconut milk (mL)	Sesame seeds (g)	Jaggery (g)	Pepper (g)	Saffron (g)	Salt (g)	Water (mL)	Coconut oil (mL)	Extract of *Dawul kurundu* (mL)	Eggs (g)
Aasmi			100													150		20					3		250	25	
Athirasa			100													60	80						5	10	250		
Kevum-Beraliya			100		20				20							100	80						2	10	250		
Kevum-Hendi			100		20								30			70	80						2	10	250		
Kevum-Konda			100		20											70	80						2	10	250		
Kevum-Kollu			100		20		100									50	100	160				14	3	10	250		1
Kevum-Mung			100	100	20											50	100	160				14	3	10	250		1
Kevum-Naran			100	25									40			50	60						3	10	250		
Kokis			100													20		160				14	3		250		1
Undu walalu			100			150										40	70	250						10	250		
Aggala-Badi haal			100													50	50				5		3	10			
Aggala-Dried rice flour								100					40			30	40						3	10			
Aggala-Habalapethi													40		100	50											
Aggala-Kos eta													40	100		50							3				
Aggala-Thala																			100	150							
Aluwa		100														70	70						3	10			
Dodol			100															550		200			5				
Gotu pittu			100										40			50	40						5				
Helapa-Hal			100		20						50	80	140			100	140							50			
Helapa-Kurahan					20							100	60			40	70						5	10			
Imbul kiribath	100												50			50	40	60					3				
Kiri roti			100													75	100	120					5				
Laveria		100											50			50	75						5	10			
Welithalapa-Madu			100							40			70			60	80							10			
Welithalapa-Rice			100										70			50	60							10			

The amounts of ingredients are presented in grams (g) for solids and milliliters (mL) for liquids. Water was added to adjust the viscosity of the batter/mixture and it can be changed.

Table 03: Main processing steps of selected traditional sweetmeats

Name of the sweetmeats	Main processing steps	Process conditions and product output
Aasmi	1. Mix the rice flour and coconut milk to make soft dough 2. Add *Dawul kurundu* extract to make final batter 3. Pour the mixture by using hand or special spoon as fine strands 4. Deep fry 5. Drain the oil and remove 6. After 2-3 days, again deep fry and decorated with coloured sugar syrup	Initial moisture content of rice flour -12-14% Viscosity of batter-20 x10^3 CP-25x10^3 CP
Athirasa	1. Caramelize portion of sugar 2. Add some water and treacle 3. Heat the mixture until getting thick sugar syrup 4. Get down from the flame and mix with rice flour to get hard mixture 5. Kneading the mixture by hand and make the dough 6. Heat the oil and frying the *Athirasa* after making into round and disk-shaped products by hand.	Initial moisture content of rice flour -16-18% Brix value of combined sugar syrup-65-70^o
Kevum-Beraliya	1. Mix all the ingredients until getting thick batter 2. If needed add some water to adjust the thickness of the batter 3. Keep the mixture for 2-3 hours 4. Pour enough batter to hot oil while spreading heated oil 5. Disturb the middle part by using wooden stick to make the knot at the middle 6. Fry until golden brown	Initial moisture content of rice flour-16-18% Viscosity of the batter-40 x10^3 CP-43.4x10^3 CP
Kevum-Hendi	1. Mix all the ingredients until getting thick batter 2. If needed add some water to adjust the thickness of the batter 3. Poured enough batter to hot oil while spreading heated oil 4. Change the sides of product to fry the both sides completely at low flame 5. Fry until golden brown and drain the oil 6. Remove from the oil	Initial moisture content of rice flour-16-18% Viscosity of the batter- 40 x10^3 CP-45x10^3 CP
Kevum-Konda	1. Mix all the ingredients until getting a thick batter, 2. If needed add some water to adjust the viscosity of the batter, 3. Keep the mixture for 2-3 hours, 4. Pour enough batter to hot oil while spreading heated oil on to the *Kevum,* 5. Disturb the middle part using wooden stick to make the knot at the middle, 6. Fry until golden brown	Initial moisture content of rice flour-16-18% Viscosity of the batter- 40x10^3 CP-45x10^3 CP
Kevum-Kollu	1. Caramelize portion of sugar 2. Add some water and treacle 3. Heat the mixture until getting thick sugar syrup 4. Mix the flour with heated sugar syrup and heat to get a hard mixture 5. Kneading the mixture by hand and make the dough 6. Flatten the dough and cut into diamond shaped pieces 7. Prepare the thick batter for coating 8. Dip the pieces in batter and deep fry until become golden brown	Initial moisture content of rice flour-16-18% Moisture content of horse gram flour-6-8% Brix value of combined sugar syrup-65-70^o Viscosity of coating batter - 25 x10^3 CP-30x10^3 CP
Kevum-Mung	1. Caramelize portion of sugar 2. Add some water and treacle 3. Heat the mixture until getting thick sugar syrup 4. Mix the flour with heated sugar syrup and heat to get a hard mixture 5. Kneading the mixture by hand and make the dough 6. Flatten the dough and cut into diamond shaped pieces 7. Prepare the thick batter for coating 8. Dip the pieces in batter and deep fry until become golden brown	Initial moisture content of rice flour -16-18% Moisture content of green gram flour-6-8\% Brix value of combined sugar syrup-65-70^o Viscosity of coating batter-25 x10^3 CP-30x10^3 CP
Kevum-Naran	1. Caramelize the portion of sugar 2. Add some water and heat the mixture until getting thick sugar syrup 3. Add the scraped coconuts and salt to prepare *Pol pani* 4. Mix the roasted green gram pieces, cashew and roasted rice flour flakes 5. Prepare small balls 6. Prepare the thick batter for coating 7. Deep fry the batter coated balls until golden brown	Initial moisture content of rice flour -16-18% Brix value of combined sugar syrup-60-65^o Viscosity of coating batter-25 x10^3 CP-30x10^3 CP
Kokis	1. Mix the ingredients to get required batter 2. Dip the hot mould in the batter 3. Then directly dip in the heated oil 4. Deep fry until it become crispy	Initial moisture content of rice flour 16-18% Viscosity of batter-25 x10^3 CP-30x10^3 CP
Undu walalu	1. Grind the black gram seeds with little water as a paste 2. Mix with rice unroasted rice flour 3. Keep for 4-6 hours 4. Adjust the thickness of the batter with water 5. Pour the batter into heated oil through a small hole made in the pack	Initial moisture content of rice flour -16-18% Brix value of combined sugar syrup-60-65^o Viscosity of batter-50 x10^3 CP-55x10^3 CP

Aggala-Badi haal	**1**. Caramolize portion of sugar 3. Add some water and treacle 4. Heat the mixture until getting thick sugar syrup 5. Mix the fully roasted rice flour with heated sugar syrup and heat to get a hard mixture 6. Low the flame and get down the mixture 7.	Initial moisture content of roasted rice flour-4-6% Brix value of combined sugar syrup-65-70^{o}
Aggala-Dried rice flour	1. Roast the cooked and dried rice until golden brown 2. Grind into flour keep aside 3. Caramelized portion of sugar and later add some water and treacle 4. Heat the mixture until getting thick sugar syrup 5. Mix the flour with heated sugar syrup and heat to get a hard mixture 6. Get down from the flame and make the balls	Initial moisture content of rice flour -4-6% Brix value of combined sugar syrup-65-70^{o}
Aggala-Habalapethi	1. Dip the dried *Habalapethi* in hot water for 2 -3 minutes 2 Drain the water the by squeezing 3. Mix with scraped coconut, sugar and treacle 4.Mix and make the balls	Moisture content of soaked habalapethi-60-65%
Aggala-Kos eta	1. Roast the jack seeds 2. Turned into small particles or flour by using mortar and pestle 3. Add the scraped coconut, sugar and treacle and again mix 4. Get the mixture and made into small balls	Moisture content of roasted jack seeds-17-20%
Aggala-Thala	1. Mix the roasted sesame seeds, dried scarped coconuts and pieces of jaggery 2. Fill the mixture into a tube 3. Cut into long pieces and cover them	Moisture content of sesame seeds-10-12%
Aluva	1. Caramolize portion of sugar 3. Add some water and treacle 4. Heat the mixture until getting thick sugar syrup 5. Mix the roasted rice flour and dried scraped coconuts with heated sugar syrup and heat to get a hard mixture 6. Low the flame and get down the mixture 7. Flatten the mixture on a wooden board 8. Keep to cool and cut into pieces	Initial moisture content of rice flour -4-6% Brix value of combined sugar syrup-50-55^{o}
Dodol	1. Caramelize the portion of sugar 2. Add some water and heat the mixture until getting thick sugar syrup 3. Add flour and mixing continuously at low flame to get required hard mixture 4. Get down from the flame and flatten to cool 5. Cut into pieces	Initial moisture content of rice flour 16-18% Brix value of combined sugar syrup-65-70^{o}
Gotu pittu	1. Mix the ingredients 2. Make the cone by using jack fruit leaves 3. Packed the cones on the steamer 4. Fill the mixture into the cones made of jack fruit laves 5. Steam	Viscosity of the batter-35x10^{3} CP -40x10^{3} CP
Helapa-Hal	1. Caramelize the portion of sugar 2. Add some water and heat the mixture until getting thick sugar syrup 3. Add the scraped coconuts and salt to prepare *Pol pani* 4.Mix the flour with sweetened coconut 5. Prepare small balls 6. Flatten on the *Kenda* leaves (*Macaranga peltata*) 7. Steam	Initial moisture content of rice flour 16-18% Brix value of combined sugar syrup-65-70^{o} `
Helapa-Kurahan	1. Caramelize the portion of sugar 2. Add some water and heat the mixture until getting thick sugar syrup 3. Add the scraped coconuts and salt to prepare *Pol pani* 4.Mix the flour with sweetened coconut 5. Prepare small balls 6. Flatten on the *Kenda* leaves (*Macaranga peltata*) 7. Steam	Initial moisture content of rice flour 16-18% Brix value of combined sugar syrup-65-70^{o}
Imbul kiribath	1. Caramelize the portion of sugar 2.Add some water and heat the mixture until getting thick sugar syrup 3.Add the scraped coconuts and salt to prepare *Pol pani* and keep aside 4.Cooked the raw rice with enough water 5.When cooked, add thick coconut milk with dissolved salt and mix properly 6.Cooked milk rice is filled on to a Banana leaf 7.Fill the sweetened coconut in the middle and folding to seal the edges	Final moisture content of cooked milk rice-48-55% Brix value of combined sugar syrup-65-70^{o}
Kiri roti	1.Mix rice flour with little sugar and coconut water 2.Keep for 4-5 hours 3.Make the batter after adding coconut milk, sugar and salt 4.Heat the specific pan used for this product 5.Pour spoonful batter into the middle section of the pan and cover 6.Spread some water around the lid 7.After few minutes get the product from the pan and directly put into the hot sugar syrup 8.Keep for 2-3mintues and drain the product	Initial moisture content of rice flour 16-18% Viscosity of the batter -65-70^{o}

Laveria	1. Caramelize the portion of sugar 2. Add some water and heat the mixture until getting thick sugar syrup 3. Add the scraped coconuts and salt to prepare *Pol pani* and keep aside 4. Mix finely sieved roasted rice flour with hot water 2. Fill into string hopper mould and squeeze on to a Banana leaf. 3. Fill the sweetened coconut in the middle and folding to seal the edges 4. Steam	Initial moisture content of rice flour -14-16% Brix value of combined sugar syrup-65-70^{o}
Welithalapa-Madu	1. Prepare *Pittu* 2. Caramelize portion of sugar 3. Add some water and treacle 4. Heat the mixture until getting thick sugar syrup 5. Mix the *pittu* with heated sugar syrup and heat to get a hard mixture 6. Low the flame and get down the mixture 7.Flatten the mixture on a wooden board 8.Keep to cool and cut into pieces	Initial moisture content of rice flour 16-18% Brix value of combined sugar syrup-50-55^{o}
Welithalapa-Rice	1. Prepare *Pittu* 2. Caramelize portion of sugar 3. Add some water and treacle 4. Heat the mixture until getting thick sugar syrup 5. Mix the *Pittu* with heated sugar syrup and heat to get a hard mixture 6. Low the flame and get down the mixture 7.Flatten the mixture on a wooden board 8.Keep to cool and cut into pieces	Initial moisture content of rice flour 16-18% Brix value of combined sugar syrup-50-55^{o}

Determination of phenolic compounds and antioxidant potential

Extraction: The sweetmeat samples dried at 60 ^{o}C were ground using a mortar and pestle and defatted with petroleum ether using a Soxhlet apparatus. The defatted food material was ground using a home-style grinder (Black & Decker, USA) and passed through a 250 µm aperture-sieve. Defatted, ground material was packed in triple laminated aluminum bags and stored at 4-6 ^{o}C until used.

Defatted sweetmeat samples were extracted using 80% (v/v) methanol as described by Fu *et al*. (2016) with some modifications. Approximately, 2.0 g of sample in Erlenmeyer flasks was added 20 mL of 80% (v/v) methanol, covered with aluminum foil, and extracted for 24 hours at room temperature while mixing in a wrist-action shaker (Biobase, China) operating at 150 rpm. The sample-methanol slurry was then centrifuged at 1500 x 10^2 g for 30 minutes, supernatant was recovered by decanting. Methanol extract was then filtered (Whatman No. 1 filter paper) and the recovered extract was evaporated in a round bottom flask using a vacuum rotary evaporator (Buchi Rotorvapor) until all solvent get evaporated and the flask reached to a constant weight. The resulting dry extract was scraped out from the flask, weighed and stored in brown glass bottles at -20 ^{o}C until further analysis. A stock solution of 1000 ppm of each sample was reconstituted in dimethyl sulfoxide and used in analyses.

Determination of total phenolic compounds

The total phenolic content (TPC) of the extracts was measured using the Folin-Ciocalteu method as described by Bhalodia *et al*. (2011). An aliquot (1 mL) of the reconstituted aqueous methanolic extract was transferred to glass test tubes, added 5 mL of distilled water and 0.5 mL of Folin-Ciocalteu's reagent (1:1 v: v) and mixed well. After 5 minutes of mixing, 1.5 mL of 20 % (w/v) sodium carbonate was added and volume was made up to 10 mL with double distilled water. The assay mixture was incubated for 2 hours at room temperature. After incubation, absorbance of the assay mixture was measured at 798 nm against a distilled water blank. A calibration curve developed with gallic acid (0–0.1 mg/mL) was used and concentration of total phenolics was expressed as gallic acid equivalents (GAE) in mg/g of dry matter of the product.

Determination of total flavonoid content

Total flavonoid content (TFC) was determined according to the method described by Thaipong *et al*. (2006). An aliquot (1 mL) of reconstituted extract was added to a 10 mL volumetric flask containing 4 mL of double distilled water. Then 0.3 mL of 5% (w/v) $NaNO_2$ was added, mixed and after 5 minutes, 0.3 mL of 10% $AlCl_3$ (w/v) was added. At the 6th minute, 2 mL of 1 M NaOH was added and the total volume was made up to 10 mL with double distilled water. The solution was mixed and the absorbance was measured at 510 nm. Total flavonoid content was expressed as quercetin equivalents (QE) in mg/g dry matter of the product.

Determination of antioxidant potential 2,2 -Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS•+) radical cation-based assays

The ABTS assay was conducted according to the method of Arnao *et al*. (2001) with some modifications. The working solution was prepared each day by mixing the two stock solutions (7.4 mM ABTS•+ solution and 2.6 mM potassium persulfate) in equal quantities and allowing to react for 12 hours at room temperature in the dark. The solution was then diluted by mixing 1 mL working solution with 70 mL methanol. A sample of 150 µL was allowed to react with 2850 µL of the ABTS•+ working solutions for 2 hours in the dark. The absorbance values of the assay mixture were read at 734 nm and the results were expressed in mM TEAP/g of product dry matter.

DPPH$^{\cdot}$ (2,2'-diphenyl-1-picrylhydrazyl radical) assay

The DPPH assay was carried out according to the method of Brand-Williams *et al*. (1995). The stock solution was prepared by dissolving 4 mg DPPH with 100 mL methanol and then stored at 20 ^{o}C until used. The working solution was obtained by mixing 10 mL stock solution with 45 mL methanol. A 150 µL of the stock solution was allowed to react with 2850 µL of the DPPH solution for 24 hours in the dark. Then the absorbance of the assay mixture was taken at 515 nm. A linear standard curve of Trolox (25 and 800 mM) was used for expressing DPPH radical scavenging ability in mM TEAP/g of product dry matter.

Ferric Reducing Antioxidant Power-FRAP Assay

The FRAP assay was conducted according to Benzie and Strain (1996) with some modifications. The stock solutions included 25 mL of 300 mM acetate buffer (3.1 g $C_2H_3NaO_2.3H_2O$ and 16 mL $C_2H_4O_2$), pH=3.6, 2.5 mL of 10 mM TPTZ (2, 4, 6-tripyridyl-s-triazine) solution in 40 mM HCl and 2.5 mL of 20 mM $FeCl_3.6H_2O$ solution was incubated at 37 ^{o}C for 10 minutes. A sample from the stock solution (150 µL) was allowed to react with 2850 µL of the FRAP solution for 30 minutes in the dark. Absorbance values of assay mixture at 593 nm was recorded. A linear standard curve of Trolox (25 and 800 mM) was used for expressing results in mM TEAP/g dry mater of the food product.

Texture profile analysis of prepared sweetmeats

The texture profile analysis (TPA) was conducted on freshly prepared foods maintained at 25 ± 2 °C for 24 hours using a CT3 Texture Analyzer (M08-372-F1116, CT3 Texture Profile Analyzer, Brookfield Engineering, USA) according to the methods described by Pereira *et al*. (2013) with some modifications. Equipment was calibrated with a 5 kg load cell and a TA7 Knife-edge probe (60 mm) with a test speed of 1 mm/s was used for testing. Product samples were placed with the top upward as they are usually presented and triplicate determinations were carried. Hardness, springiness, cohesiveness and chewiness were calculated from the force/time curves obtained in TPA (Figure 01). Hardness

was measured as the force (g) required for a predetermined deformation and it is interpreted as peak force (F1) in the curve. The chewiness was measured as the energy required to chew a solid food until it is ready for swallowing. The chewiness was calculated as the multiplication of hardness, cohesiveness and springiness.

Statistical analysis

All experiments were performed in triplicates and were expressed as the Mean± Standard Deviation. All statistical analysis was performed using analysis of variance. Tukey's multiple range test was conducted to estimate the significant differences among the means at 5% probability level. Data analysis was carried out with Minitab 19 software.

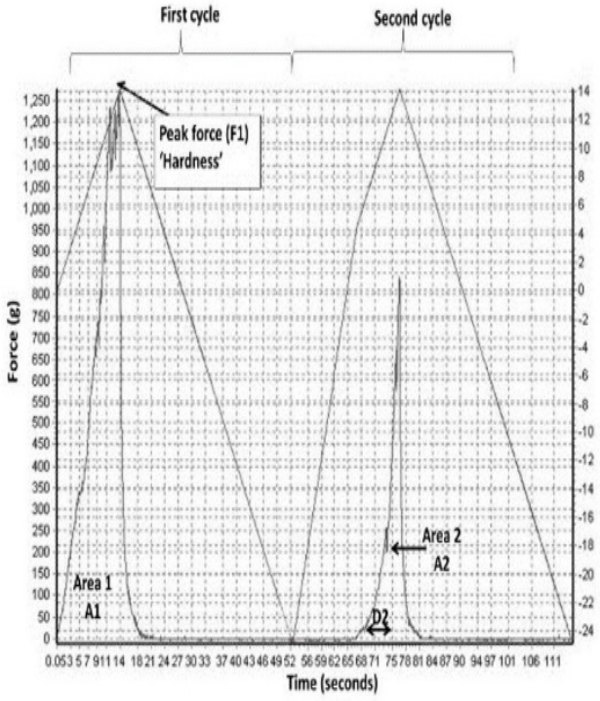
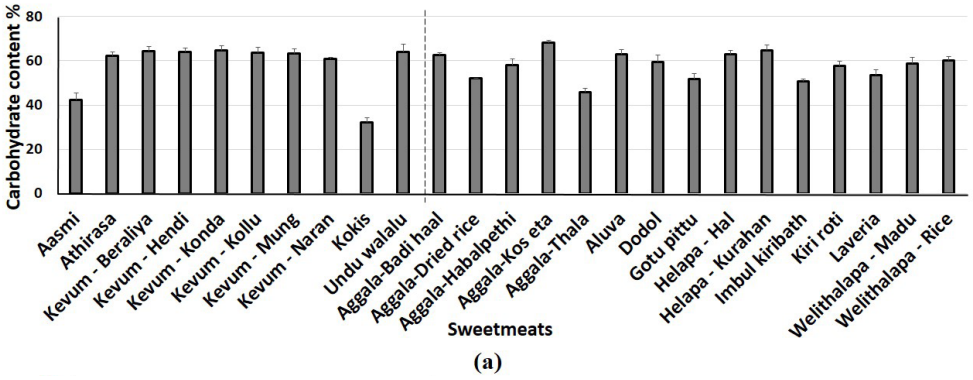


Figure 01: **A representative texture profile analysis curve for sweet meat products. First cycle represents the 1st compression and 1st withdrawal at the 1st bite and second cycle represents the 2nd compression and 2nd withdrawal at the 2nd bite.**



(a)

Figure 02: **Macronutrient levels of the selected Sri Lankan traditional sweetmeats for 100 g of fresh weight (a) Carbohydrate content (%), (b) Fat content (%) and (c) Protein content (%). Products to the left of the dotted line are deep fried and the non-deep fried sweetmeats are to the right.**

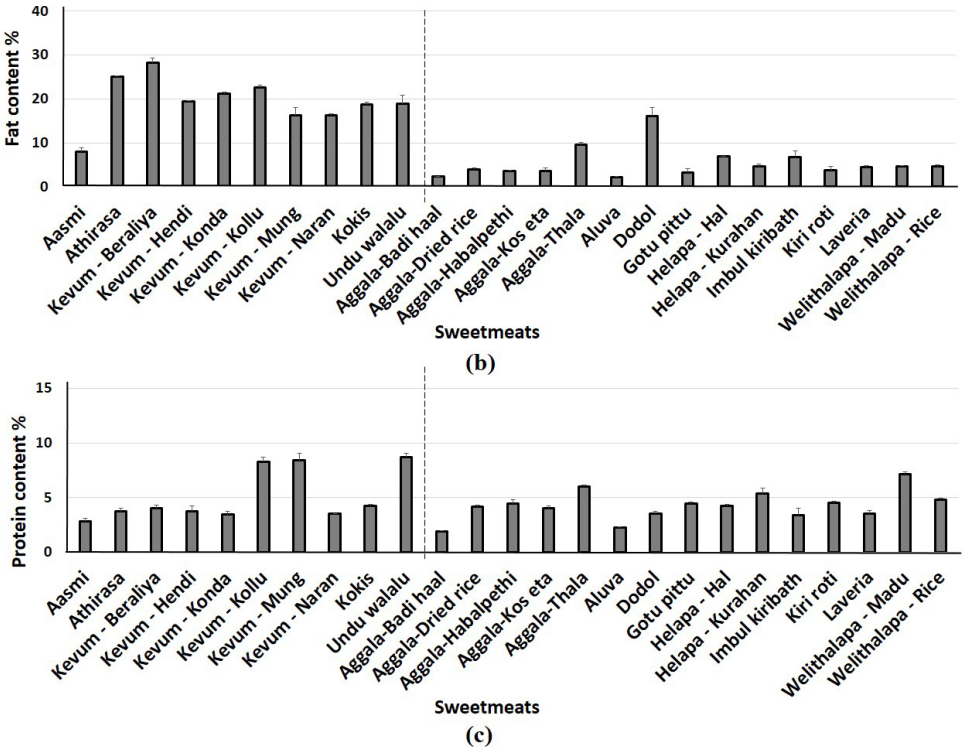


Figure 02: **Macronutrient levels of the selected Sri Lankan traditional sweetmeats for 100 g of fresh weight (a) Carbohydrate content (%), (b) Fat content (%) and (c) Protein content (%). Products to the left of the dotted line are deep fried and the non-deep fried sweetmeats are to the right.**

RESULTS

Macronutrient content and energy intake of the selected Sri Lankan traditional sweetmeats

Considerable variations in macronutrient levels of the selected traditional sweetmeats were expected due to usage of diverse ingredients in different proportions and different processes in different manner for the 25 traditional sweetmeat preparations. The cereals and pulses that were used as flour sources and the sweetening agents in the formulation contributed to the total (simple and complex) carbohydrates of the traditional sweetmeats. When all the sweetmeats are considered, the total carbohydrate content ranged from 32.29±1.97% to 68.05±1.30% (Figure 02a) with the lowest for *Kokis* (32.29±1.97%) and the highest for *Kos eta aggala* (68.05±1.30%).

The carbohydrate content of the deep-fried sweetmeats ranged from 32.29±1.97% to 64.79±1.98% with no significant difference ($p>0.05$) among the batter coated, non-batter coated and other types of sweetmeats except *Aasmi* and *Kokis.* Among non-deep fried sweetmeats, *Aggala* made of Jack seeds (*Kos eta aggala*) reported the highest carbohydrate content while other *Aggala* formulations had much lower levels. *Aluva, Madu welthalapa, Welithalapa, Hal helapa* and *Kurahan helapa* that were formulated with sugar syrup and treacle had higher carbohydrate content that was similar to deep fried products, but lower than *Kos eta aggala*.

The fat content of the all sweetmeats of this study was in a range of 2.3±0.04% to 28.23±1.06% (Figure 02b). As expected, the fat content of deep-fried sweetmeats was significantly ($p<0.05$) higher compared to non-deep-fried products except *Dodol* (~ 20%) and followed the order of *Beraliya kevum* (28.23±1.06%) > *Athirasa* > *Kollu kevum* > *Konda kevum* > *Hendi kevum*> *Undu walalu* > *Kokis*> *Mung kevum* = *Naran kevum*> *Aasmi* (7.97±0.96%). Among the *Kevum* products that are not batter coated before frying, *Beraliya kevum* reported the highest fat content

compared to *Konda kevum* and *Hendi kevum*. Despite this, the batter coated *Kevum* products (*Naran kevum, Kollu kevum* and *Mung kevum*) showed a lower fat content than the deep-fried non-batter coated *Kevum*. The other deep-fried sweetmeats, *Athirasa* (25.14±0.14%) reported the second highest fat content. Although, the product is deep fried two times in the process of preparation, among the deep-fried category, the lowest (7.97±0.96%) fat content was reported for *Aasmi*. In the non-deep-fried sweetmeat category, except *Dodol*, the fat content ranged from 2.3±0.04% to 9.57±0.62%. *Badi haal aggala* (2.3±0.04%) which was formulated with roasted rice flour and sweetening agents reported the lowest fat content while other *Aggala* formulations with addition of jack fruit seeds, dried rice or sesame seeds exhibited comparatively higher fat content. *Dodol* contained a significantly ($p<0.05$) higher fat content (16.19±1.87%) among the non-deep-fried items. Moreover, sweetmeats that used coconut milk or scraped coconut in the formulation had comparatively higher fat content than other non-fried sweetmeats.

The protein content of these 25 sweetmeat products was in the range of 1.91±0.08% to 8.70±0.33% (Figure 02c). The flour base (cereal or pulse), and coconut milk primarily contributed to the proteins of the sweetmeat products. Among the products, a significantly ($p<0.05$) higher protein content was recorded for sweetmeats containing pulses (black gram, horse gram, and green gram) in the formulation than others. *Undu walalu* that contain black gram and rice flour had the highest protein level of 8.70±0.33% followed by *Mung kevum* and *Kollu kevu*m. Of the different *Kevum* formulations, the batter coated *Naran kevum* and other non-batter coated *Kevum* products with no pulses in the formulation had low protein content (3.45±0.32 to 4.03±0.29%). Among the non-deep-fried products, a significantly ($p<0.05$) low protein content was reported for *Bedi haal aggala* (1.91±0.08%) which contain only roasted rice flour and sugar syrup in the formulation. Other *Aggala* products had ingredients other than rice flour or differently processed rice (Table 01) reported higher protein content than *Bedi haal aggala*; *Kos eta aggala* (4.01±0.24%), *Dried rice aggala* (4.17±0.13%) and *Thala aggala* (6.01±0.14%). The protein content of *Walithalapa* (4.8±0.18%) significantly ($p<0.05$) increased up to 7.13±0.21% when Cycas seeds flour was in the formulation in addition to rice flour, coconut and sugar syrup. Similarly, the protein content of *Hal helapa* (4.26±0.10%) showed an increase when finger millet flour was in the formation (*Kurahan helapa*, 5.37±0.46%).

Almost all the traditional sweetmeats of this study can be considered as energy-dense foods (Figure 03) with the energy intake from the products ranging from 251.42 kcal/100 g (*Aasmi*) to 527.33 kcal/100 g (*Beraliya kewum*).

Based on the results, deep-fried sweetmeats that contained higher fat content provide higher energy level than non-fried sweetmeats, with *Dodol* (397.94 kcal/100 g) being an outlier. Among the batter-coated different *Kevum* formulations, *Mung Kevum* (491.05 kcal/100 g) reported the higher energy value than *Naran-* (489.67 kcal/100 g) or *Kollu* (404.23 kcal/100 g) *Kevum*. It is observed that, *Aasmi* and *Kokis* had the lowest energy value among all the deep-fried sweetmeats.

Considering the four types of *Aggala*, *Dried rice aggala* that contained dried and roasted cooked rice flour had the highest energy value (337.67 kcal/100 g) followed by sesame seeds added *Thala aggala*. *Helapa* (*Hal, Kurahan*), *Gotu pittu, Imbul kiribath, Kiri roti, Laveriya* and *Welithalapa (*Rice*, Madu)* that contain coconut derived products (scraped kernel particles of extracted milk) in addition to cereal flours and sweeteners had energy values between 255.11 kcal/100 g and 292.67 kcal/ 100 g. *Aluva*, which is a very low moisture containing product made of rice flour and sweetener had much higher energy value (320.68 kcal/100 g) than many of the non-deep fried products and the value showed no significant difference ($p>0.05$) with *Aggala* made of sesame seeds (315.34 kcal/100 g). The highest energy value among non-deep-fried products was reported for *Dodol* which contain ingredients high in carbohydrates and fat (Table 04).

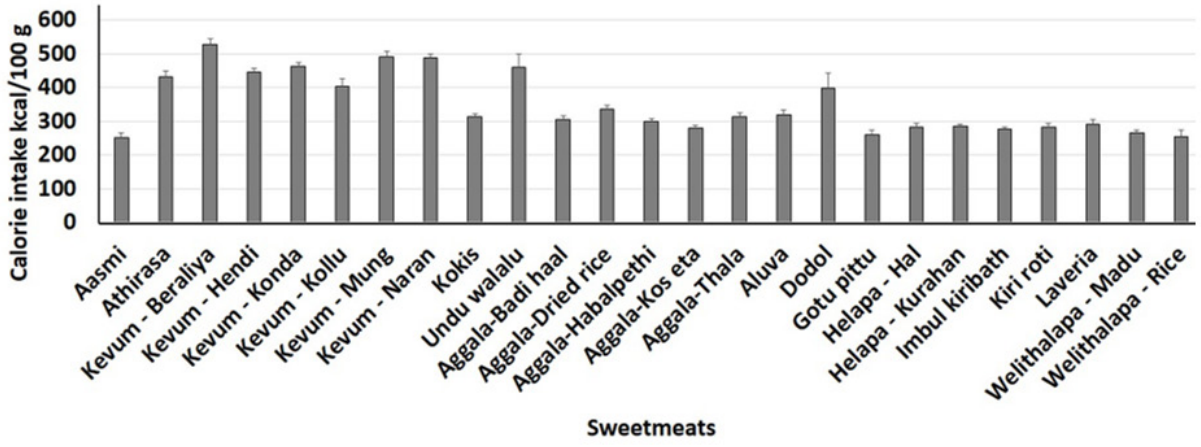


Figure 03: Energy intake from the selected traditional sweetmeats (kcal for 100 g of fresh weight).

Contents of total phenolics and flavonoids and the antioxidant potential

Both the ingredients and the processing methods may have contributed to the variations observed in the contents of extractable phenolic compounds that is reflected as total phenolic content (TPC, Figure 04a), total flavonoid content (TFC, Figure 04b) and antioxidant potential (Figure 05a, 05b and 05c) of the 25 traditional sweetmeats. The contents of total phenolics and total flavonoids of the products followed a same pattern. Of the deep-fried products, the lowest total phenolic content was for *Kokis*, followed by *Athirasa*. Rice flour is the main base for *Kokis* and coconut milk is an extract of water-soluble components of coconut scrapings. Therefore, contribution to phenolics is primarily red rice. The highest phenolics and flavonoids were reported for *Kollu kevum, Naran kevum* and *Beraliya kevum*; 1.46±0.02-1.49±0.13 GAE mg/ g DM for total phenolics and 0.58±0.08-0.63±0.07 QE mg/ g DM for total flavonoids. Other deep-fried products were in the decreasing order for total phenolics as *Undu valalu* (1.28±0.16 GAE mg/ g DM) > *Aasmi* > *Mung kevum* > *Konda kevum* > *Kokis* > *Hendi kevum* > *Athirasa* (0.61±0.07 GAE mg/ g DM) and *Undu walalu* (0.50±0.10 QE mg/ g DM) > *Mung kevum* > *Aasmi* > *Konda kevum* > *Kokis* > *Athirasa* > *Hendi kevum* (0.21±0.10 QE mg/ g DM) for total flavonoids.

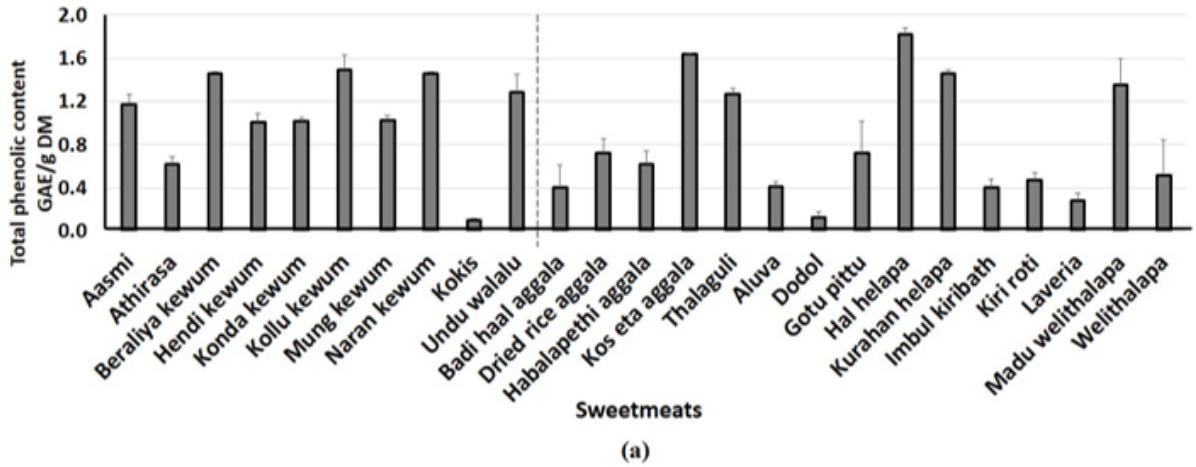


Figure 04: The contents of (a) Total phenolics, and (b) Total flavonoids of selected traditional sweetmeats. Products to the left side of the dotted line are deep fried and to the right are non-deep fried.

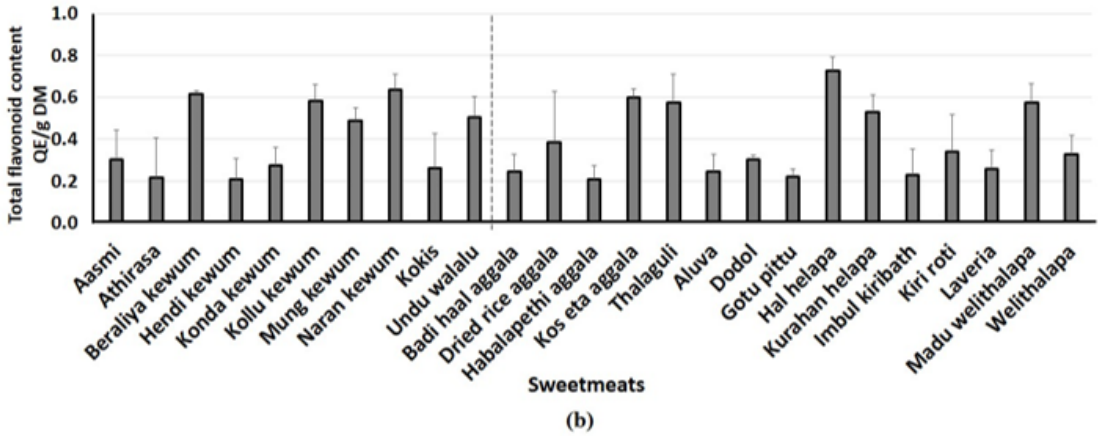


Figure 04: **The contents of (a) Total phenolics, and (b) Total flavonoids of selected traditional sweetmeats. Products to the left side of the dotted line are deep fried and to the right are non-deep fried.**

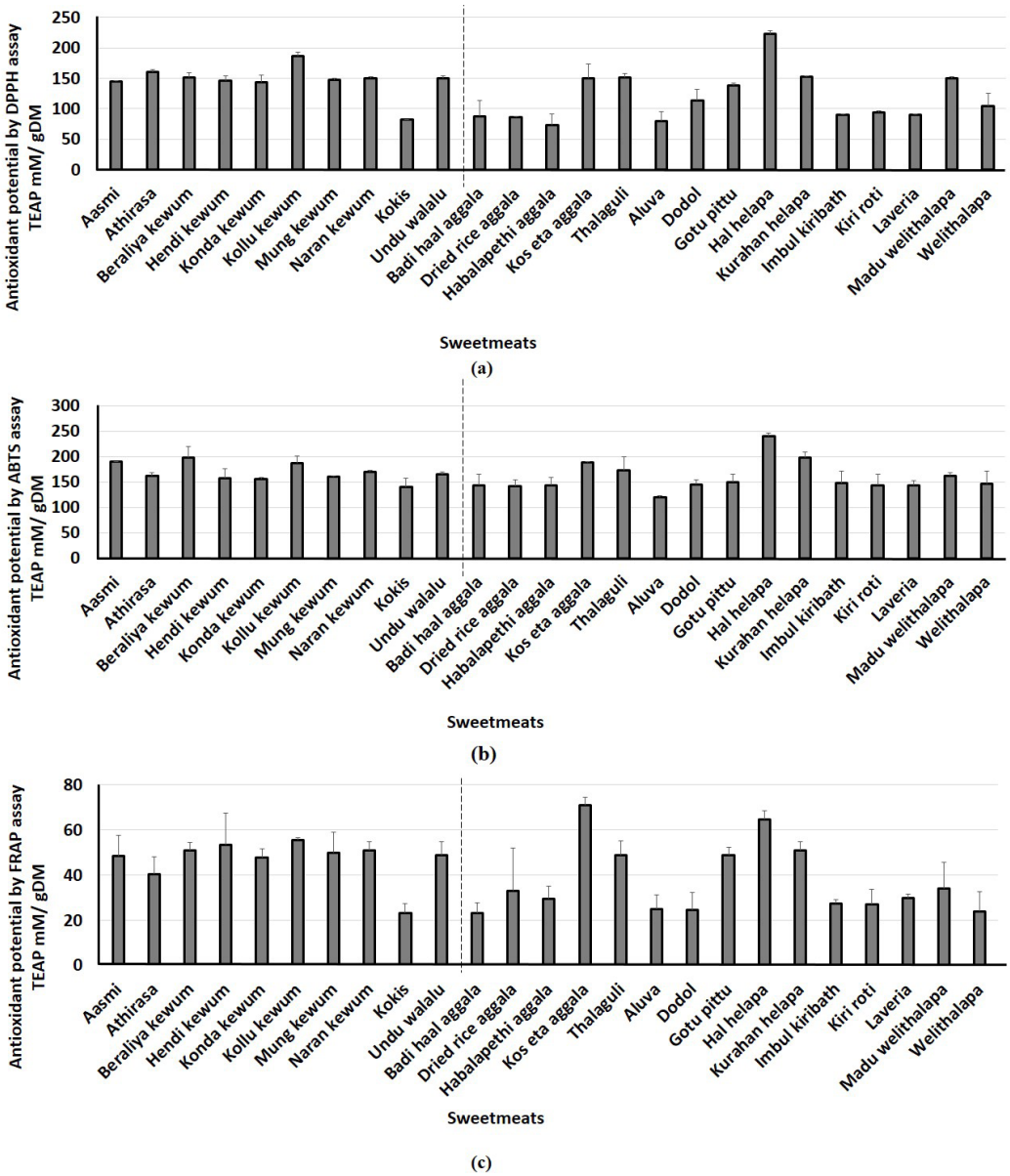


Figure 05: **Antioxidant potential of selected traditional sweetmeats by (a) DPPH assay, (b) ABTS assay, and (c) FRAP assay. Products to the left side of the dotted line are deep fried and the non-deep-fried sweetmeats are to the right.**

Among the non-deep-fried sweetmeats, *Hal helapa* reported the highest contents of total phenolics TPC (1.82±0.06 GAE mg/ g DM) and TFC (0.72±0.0.07 QE mg/ g DM). Besides that, *Kos eta aggala*, *Thala aggala*, *Kurahan helapa* and *Madu welithalapa* had significantly ($p<0.05$) higher total phenolics and flavonoids levels than other products. Among different formulations of *Aggala,* roasted jack seeds added *Aggala* recorded the highest TPC (1.64±0.01 TPC as GAE mg/ g DM) and TFC (0.59±0.04 QE mg/ g DM). All other products were in the range of 0.13±0.05 to 1.45±0.04 GAE mg/ g DM TPC and 0.21±0.07 to 0.57±0.09 QE mg/ g DM for TFC. It was clear from the data that, dried Shorea flowers, horse gram, green gram, black gram, *Dawul kurundu* extract, jack seeds, Cycas seed flour, Vateria seeds and finger millet added sweetmeats reported comparatively higher TPC and TFC than the products made of rice flour alone as the main flour base in the formulation.

Antioxidants potential of selected traditional sweetmeats determined by three assays are presented in Figure 05a-05c. Of the deep-fried products, *Kollu kevum* stood out as the sweetmeat with the highest ability to scavenge lipophilic (DPPH assay) free radicals (Figure 05a) and the highest antioxidant potential (Figure 05c). *Kokis* showed the lowest value among deep fried products for all three assays. Among the non-deep-fried products, *Hal Helapa* was reported the highest ability to scavenge free radicals DPPH (222.44±5.34 TEAP mM/ g DM) and ABTS (240.28±5.62 TEAP mM/ g DM) while *Aggala* made of jack seeds (70.77±3.78 TEAP mM/ g DM) gave the highest antioxidant potential by FRAP assay. Among different *Aggala* formulations, *Aggala* formulated with jack seeds and sesame seeds showed the increased antioxidant potential by three assays compared to rice based *Aggala* formulations. Although not as high as *Hal helapa*, free radical scavenging ability and antioxidant potential of *Kurahan helapa* made of finger millet flour was higher than other non-deep-fried products. All other non-deep-fried products have fairly close values for free radical scavenging ability and antioxidant potential (Figure 05a-05c).

Textural properties of selected traditional sweetmeats

The texture that is felt by hand and also in the mouth is unique for each of the Sri Lankan traditional sweetmeats and a highly valuable sensory property besides their delicious taste. Textural properties such as hardness and chewiness felt at the first bite are related to the overall acceptability of the foods. Among the products of the present study, hardness and chewiness properties varied between products reflecting their inherent properties (Figure 06a-06e). Hardness values of the products were in the range of 4599 g to 1057 g. The chewiness, the energy required to chew solid food until it is ready for swallowing, varied from 4.5 mJ to 35 mJ (Figure 06a-06e).

Among the *Kevum* products, there is a clear difference how batter-coated and non-batter coated products are placed in the TPA space (Figure 06a). The non-batter coated *Kevum* products were harder and less-chewier than the batter coated products which were placed higher in the chewiness scale. Comparison of values for *Beraliya kevum* with *Konda kevum* provided how supplementing ingredient affect texture as *Beraliya kevum* was bit harder than regular rice flour-sweetner containing *Konda kevum*. Interestingly, *Hendi kevum* and *Konda kevum* has the same ingredient and formulations only the difference is no knot formation, and had almost similar hardness and chewiness values (Figure 06a). Although not coated with batter, *Athirasa* is more particulate and had closer values as other non-batter coated *Kevum*. *Kokis* and *Aasmi*, were in the lower hardness scale (Figure 06b) among the deep-fried products as they supposed to be crispy sweetmeats that must break easily at the first bite. *Undu walalu* which is not a batter coated product was placed close to batter-coated *Kevum* products than non-batter coated in the TPA space (Figure 06b). Among different *Aggala* types (Figure 06c), *Badi haal aggala* was less-harder and less-chewier than others. Supplementing ingredients showed the effect on hardness and chewiness of the product as exemplified from *Aggala* containing jack fruit

seeds or sesame seeds (Figure 06c). There was not much difference observed for hardness and chewiness values for *Madu Welithalapa* and rice flour based *Welithalapa,* most likely the granular nature of *Pittu* is the main determining factor for TPA parameters (Figure 06e). All the *Aggala* types and all other non-deep-fried sweetmeats were in the lower range of hardness (< 3000 g) except *Dodol* and *Hal helapa*. When *Vateria copallifera* seeds containing *Hal helapa* and *Kurahan helapa* formulated with finger millet flour is considered higher hardness and chewiness values were reported for *Hal helapa* (Figure 06d). *Dodol* was an exception and placed separately in the TPA space with higher hardness and chewiness values (Figure 06e).

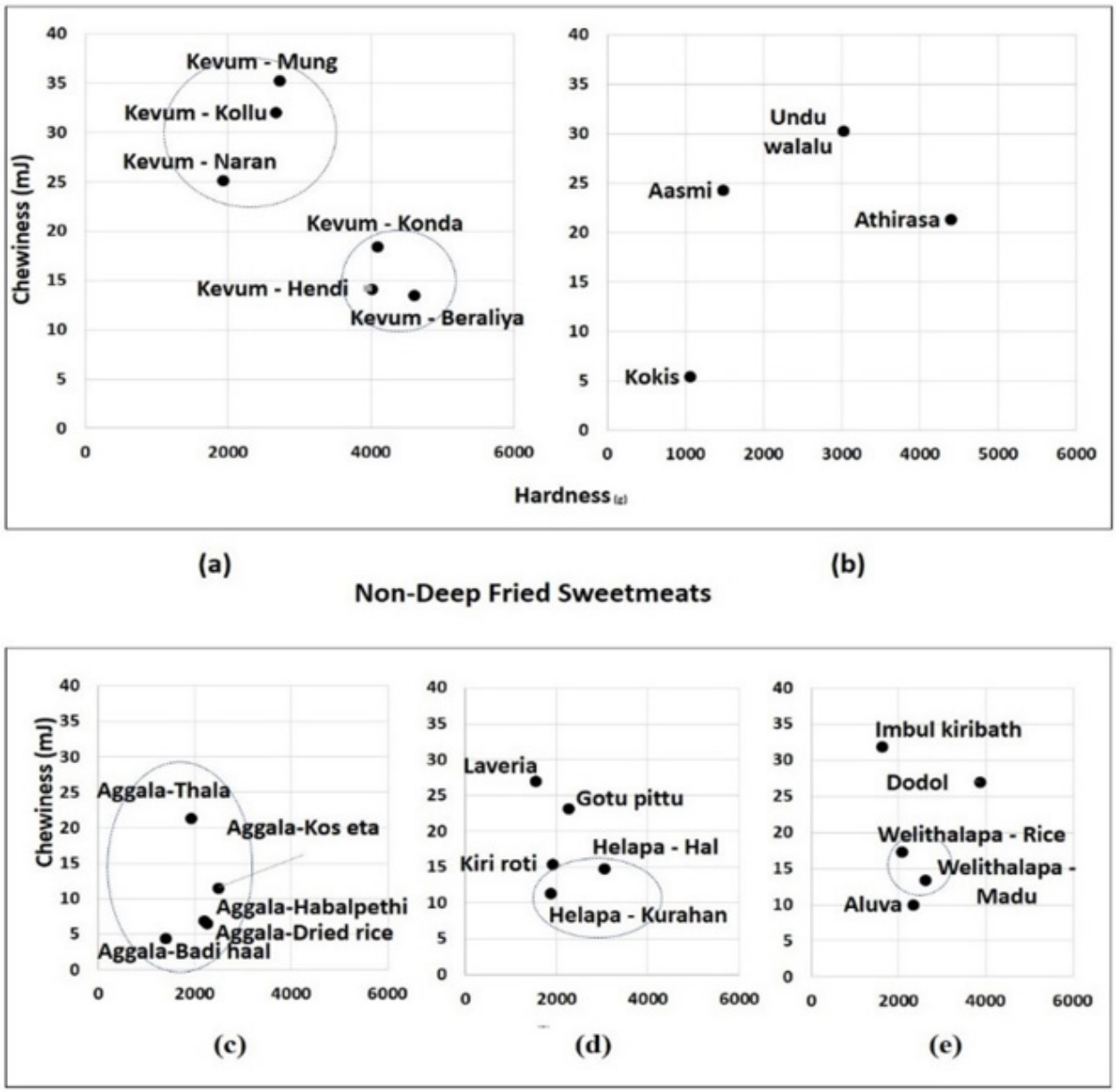


Figure 06: Hardness and Chewiness of selected traditional sweetmeats

(a) Deep-fried Kevum products, (b) Other deep-fried products, (c) Non-deep fried Aggala products, (d) Non-deep fried products with different shapes (e) Non-deep fried products made after flattening and cutting into diamond or square shapes. Products circled in dotted lines are processed similarly but have different ingredients supplementing main flour base.

DISCUSSION

Traditionally, sweetmeats are snacking foods that are often deserts and have a special place in ceremonies and festivities, Sinhala-Hindu New year season in particular. Sweetmeats are often served with banana and a hot cup of tea which is a traditional practice to welcome the visitors in Sri Lankan household. Consumption of a sweetmeat after the main meal is an ancient tradition and a practice. Traditional sweetmeats are popular without geographical or age limits.

Of the three macro-nutrients (total carbohydrates, fat and protein) analyzed in this study, carbohydrates have higher contribution to the caloric value as a source of energy of a given food. Flours of cereals and/or pulses and sweeteners indigenous to the locale are the main ingredients for the traditional sweetmeats of the present study and it is clear from the high levels of total carbohydrates of the products (Table 04).

Rice flour is the mostly used starch base and mung bean, horse gram, finger millet or black gram flour are supplemented to have product variation for taste, texture as well as nutritional profile. Among the different types of rice varieties and types available since ancient times, red rice that not parboiled (*Rathu kakulu*) was used oppose to white rice. Red rice brings additional red-brown colour to final products and also increases complex carbohydrate level. It is reported that traditional rice varieties such as *Madathawalu, Heenati* and *Kalu heenati* etc. that are from heirloom rice have higher amounts of dietary fiber and resistant starch, antidiabetic properties than the purpose-bred improved rice varieties widely cultivated in present days (Ginigaddara and Disanayaka, 2018; Abeysekera *et al*., 2017). Depending on the product, particle size and moisture content of the flour source are significant considerations in the pre-preparation for the formulations. The starches of flour sources undergo further dehydration such as roasting needed for *Aluva* or gelatinization for *Laveriya* (similar to String hopper preparation) as pre-processing steps. According to Farooq *et al*. (2018), starch gelatinization of main flour ingredient during thermal processing creates unique structures, textures and tastes of the products when sufficient water is present.

Traditional sweeteners used in these sweetmeats are, treacle and *jaggery* (*Caryota urens* or *Cocos nucifera*) and rarely bee honey, which are replaced mostly by cane sugar in present day preparations. These sweeteners are rich in simple carbohydrates, primarily sucrose and glucose or fructose (Bobis *et al*., 2018). Brown sugar is the raw, moist and dark sugar obtained upon dehydrating sugar cane syrup, without refining and contain 94–98.5% of sucrose (Zaitoun *et al.,* 2019). The inflorescence sap of *Caryota urens* or Kithul palm is rich in simple sugars and the base for treacle and jaggery production (Somasiri *et al*., 2012). Sugars of these sweeteners not only add sweetness, but gives consistency, glossy appearance, texture and participate in brown color formation (Stieger, 2011) of the final product. The unaltered *Kithul* treacle exerts several health effects (Senevirathne and Dissanayaka, 2016) including low Glycemic Index (GI) therefore, considered suitable for diabetic patients (Adikari *et al*., 2018). Compared to complex carbohydrates, simple sugars increase blood sugar levels quickly while giving high glycemic index to foods containing them (Eleazu, 2016). Recently, Wimalasiri *et al*. (2016) reported that alpha-glucosidase inhibitory activity of *Caryota urens* sap and treacle may link to their anti-diabetic properties. In addition, *Kithul* treacle has a different nutrient profile than cane sugars which includes several plant secondary metabolites of inflorescence sap, such as some free amino acids which may provide additional health benefits besides being low GI.

Table 04: Macro-nutrient information of main ingredients used in traditional sweetmeat products

Name of the ingredient	Carbohydrates %	Fat %	Protein %	References
Red rice flour	81-85	1.8	7.5	Abeysekera *et al*., 2017
Green gram flour	61	1.22	23.8	Dahiya *et al*., 2015
Horse gram four	57.2	0.5	22	Bhartiya *et al*., 2015
Black gram flour	51.5	1.44	26.7	Girish *et al*., 2012
Finger millet flour	86.9	1.4	8.7	Jayawardana *et al*., 2019
Sesame seeds	24.5	50.8	18.0	Prasad *et al.,* 2012
Cycas flour	50		10.0	Senadheera and Ekanayake, 2013
Jack seeds	83.6	0.56	9.7	Amadi *et al*., 2018
Scraped debittered Vateria seeds	45.6	5.2	4.0	Mihiranie *et al*., 2019
Coconut milk 1:1 (w/v)	2.2	3.1	5.8	Karunasiri *et al*., 2020
Scraped Coconut	12.3	37	7.5	Appaiah *et al*., 2014

Most of the sweetmeats of this study are either deep fired or had coconut and coconut milk as ingredients. Coconut milk, fresh scraped coconut, and oil-rich seeds such as cashew nut and sesame seeds also contributed to the fat content of these preparations. The traditional deep-frying medium for the sweetmeats is coconut oil which was used in this study. Deep frying is a thermal processing step that the product is submerged in oil maintained at near boiling point to achieve desired taste, colour and texture. The products that are high in starch absorb a significant amount of fat from deep frying and consequently result in high fat content as observed in the deep-fried products of the present study. Coconut oil contains medium-chain fatty acids (MCFAs) which impart considerable health benefits. MCFAs (C6:0, C8:0, C10:0, C12:0) are smaller and utilized as energy rather than storing in the body (Boateng *et al*., 2016). Although deep-fried, *Aasmi* reported low fat content among deep fried products and the *Neolitsea cassia* (*Davul Kurundu*) leaf extract in the formulations may have reduced oil absorption. Weerasekara and Navaratne (2015) showed reduction of oil absorption of the deep-fried food products when *Davul kurundu* water extract is included in food coating. All deep-fried sweetmeats retained some oil due to entrapment and absorption by frying starch and protein containing flours therefore, high in calories as 1 g of fat delivers 7 kcal to the human body.

Among non-fried products, *Dodol* reported higher fat content than others because of the coconut milk (Amarasiri and Dissanayaka, 2006) and sesame seeds (~ 5% oil, Table 5) in the formulation. The fat content of Shorea fruits has not been reported. A botanically close species of *Shorea robusta* seeds has been reported to contain 23.36 ± 0.11% fat content (Kumar *et al*., 2016).

Protein-rich flour sources such as, black gram, green gram, horse gram, finger millet, or Cycas flour and other ingredients such as sesame seeds and cashew adds to the total protein value of the sweetmeats of this study. These supplementations improve taste and texture of the product as well. In terms of essential amino acids supply, blending cereals (rich in methionine and cysteine) with legumes (rich in lysine) is recommended as complementing sources therefore, the sweetmeats containing black gram, horse gram and mung bean may have better essential amino acid profile than the products with rice flour alone.

In the preparation of Sri Lankan traditional sweetmeats, sweetener syrup is heated to soft ball stage, primarily to get the desired texture that attains upon cooling especially, when the flour and sweetener at this stage is mixed, flour matrtix texturizing is enhanced. In addition, heating of sweetener adds flavour and aroma development of the final product through non-enzymatic browning particularly via

caramelization and the Maillard reaction (Liang *et al*., 2018). Caramelization, or the oxidation of sugar, is a reaction that occurs during dry heating above temperatures of 110 °C. This process will yield volatile compounds, which contribute to desirable aromas, and large polymers, which are responsible for brown colors and additional texture (Nagai *et al*., 2018). For some of the sweetmeat products, to enhance brown colour, caramelized sugar is used in sugar syrup preparation. Maillard reaction occurs between the free amino groups of proteins/amino acids and reducing sugars, therefore cannot expect to happen in syrup preparation using brown sugar unless residual amino acids are found due to un-refined form. Simple sugars which have reducing functional groups such as keto- or aldo- react with amino groups in the system (free amino acids or proteins of flours or free amino acids of treacle coming from inflorescence sap), to initiate a cascade of complex reactions that ultimately leads to the generation of aroma compounds and melanoidins (brown pigments that impart color in foods) (Tamanna and Mahmood, 2015). Melanoidins differ from compounds that cause caramel color due to the incorporation of amino groups in their structure. Flavor compounds of Maillard reaction products include aldehydes, ketones, nitrogen, sulfur-containing heterocyclic compounds, which are produced by dehydration and fragmentation of sugars, amino acids, or intermediate compounds, and impart sweet, brown, roasted, toasted, and nutty aromas which could be desirable for the final product (Lund and Ray, 2017). Most of the *Kevum* products (except the batter coated) are fully cooked when deep fried until a reddish-brown skin is formed; that is associated with Maillard reaction products formed with free amino groups of rice flour protein and reducing sugars of the ingredients at temperatures of boiling oil.

Coconut kernel products such as fresh scraped coconut, coconut oil and coconut milk were included in many of the formulation of these 25 traditional sweetmeats. Sweetened coconuts formulated with fresh scraped kernel sweetened with sugar syrup (with or without caramelization) or palm treacle is widely used either as a filling (e.g., *Imbul kiribath, Laveriya*) or mixed with the flour base (e.g, *Helapa*). Fat, proteins and cell wall fibres contribute to create the unique texture of the filling and the sweetmeat. In the present study, the sweetened coconut kernel containing sweetmeats had higher fat and protein content compared to the same sweetmeat formulated with only flour and sweeteners. Patil and Benjakul (2018) reported that, the proteins of coconut kernel are rich in essential amino acids (71% to 77%).

Natural compounds of the ingredients and compounds generated during processing contributes to the antioxidant potential of these sweetmeats. In addition to the main ingredients the dry aromatic spices such as black pepper, cardamom, cloves, cumin, ginger, and nutmeg that naturally contain various forms of antioxidative compounds were part of the formulations mainly for flavoring purpose. According to the free radical-based assays, it was revealed that, stable antioxidants present in these traditional sweetmeats have the ability to scavenge free radicals in the aqueous medium (ABTS assay) or more hydrophobic environment (DPPH radical assay) rather than exerting antioxidant activity through reducing power. In these sweetmeats, the caramelized products and products formed during Maillard reaction may also have contributed to antioxidant capacity in addition to the inherent compounds such as phenolic compounds and flavonoids (Pérez-Hernández *et al*., 2012).

Kausar *et al*. (2019) have reported that caramelized products are able to reduce the DPPH radical to the yellow-colored diphenylpicrylhydrazine suggesting that intermediate products also contribute to free radical scavenging ability in addition to the compounds of early stages of browning reactions (Manzocco *et al.,* 2000). Ranasinghe *et al*. (2012) showed that sap obtained from the *Caryota Urens* is rich in antioxidant activity in terms of free radical scavenging, electron-donating and metal ion chelating activities that can impart to the final product.

Of the sensory properties of the products, texture is defined as the sensory and functional indicator of the structural, mechanical, and surface properties of foods that can be perceived by senses of sight (visual texture), sound (auditory texture), touch (tactile texture), and kinesthetic (Szczesniak, 2002). Texture profile analysis (TPA) is a popular double compression test for determining instrumental texture properties of foods, however does not completely replace subjective human evaluation (González *et al*., 2018). Texture attributes, such as hardness, crispness, and the fracturability of foods are important to consumers and manufacturers in different aspects. The 25 sweetmeats of this study are not possible to compare together for texture properties because of the nature of the products; different sizes and forms, large particles, granules of different sizes, batter coated, etc. In addition, the processing method and the product form make it more difficult to have an assessment across all products. For example, fine strands of *Aasmi* is fried, in *Laveriya* flour strands are steamed and with a filling, and in *Aggala* and *Aluva* the flour formulation was compacted but had different particle sizes. The fracturability of the products were not possible measure and compare.

Results of the present study show that additional calorie intake when sweetmeats are consumed as snack items between main meals, stressing the importance of considering macro-nutritional information and calorie intake through traditional sweetmeats in balancing daily calorie intake. Jayawardena *et al*. (2014) established the daily energy intake of healthy adult Sri Lankans to be 1912 kcal/day. In the same study, the mean daily intakes of carbohydrates, protein and fats were 304.4 g, 44.6 g and 35 g respectively. Intake of carbohydrates, proteins, fats and calories of sweetmeats vary depending on the product and the portion size. Therefore, the nutritional information of traditional sweetmeats is very important for food composition database to make recommendations to the consumer according to their health status, especially with the non-communicable diseases.

The variations that choice of ingredients can make in the nutrient composition as well as functional value such as antioxidant potential of traditional sweetmeats show these energy dense foods have some degree of health benefits. Traditional sweetmeats, if formulated with traditional, less refined ingredients rich in phytochemicals, they can be replacements for present day snacking foods that are rich in refined carbohydrates, fats, and salts and also low in micro-nutrient density, particularly for younger generation.

CONCLUSION

Macronutrient compositions of the Sri Lankan traditional sweetmeats varied due to the diverse types of traditional food ingredients in the formulations and different processing method involved in making them. As the name implies traditional sweetmeats contain higher total carbohydrate content from the starch source and the sweetner. These sweetmeats can be considered as energy-dense foods. Apart from the calorie intake, these foods can deliver bioactive compounds particularly phenolic compounds and flavonoids. These compounds together with the compounds of non-enzymatic browning that are formed during preparation, especially during deep frying contribute to antioxidant potential. The 25 traditional sweetmeats of this study are completely based on plant derived ingredients and providing macro-nutrients and also several other nutrients that originate from ingredients in the formulations in addition to the compounds generated during processing. The findings of this research can be utilized to form a food database on Sri Lankan traditional sweetmeats to make guidelines for the dietary planning and can help in making food choices. This basic nutritional information on Sri Lankan traditional sweetmeats can be utilized to increase the awareness among the general consumer so they make healthy choices.

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Conflicts of Interest

All authors have no conflicts of interest to declare.

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